Contents

WARRANTY

We warrant that each new instrument manufactured and sold by us is free from defects in material and workmanship, and that, properly used, it will perform in full accordance with applicable specifications for a period of two years after original shipment. Any instrument or component that is found within the two-year period not to meet these standards after examination by our factory, District Office, or authorized repair agency personnel will be repaired or, at our option, replaced without charge, except for tubes or batteries that have given normal service.

Type 1396-B Tone-Burst Generator

A

West Concord, Massachusetts U.S.A. 01781
Form 1396-0101-A
July, 1968
ID-B765

Specifications

SIGNAL INPUT (signal to be switched)

Amplitude: Proper operation results from input signals of not greater than 10 V pk (7 V rms) and not less than 1 V pk-pk.

Frequency Range: Dc to 2 MHz.

Input Impedance: 50 kΩ, approx.

TIMING INPUT (signal that controls switch timing). Same specifications as SIGNAL INPUT except:

Input Impedance: 20 kΩ, approx.

SIGNAL OUTPUT

Output On: Replica of SIGNAL INPUT at approx same voltage level; dc coupled; down 3 dB at >1 MHz. Output current limits at >25 mA pk, decreasing to >15 mA at 2 MHz. Output source impedance typically 25 Ω increasing above 0.2 MHz. Total distortion contribution <0.3% at 1 kHz and 10 kHz.

Output Off: Input-to-output transfer (feedthrough), <−60 dB, dc to 1 MHz, increasing above 1 MHz.

Spurious Outputs: Dc component and change in dc component due to on-off switching (pedestal) can be nulled with front-panel control. Output switching transients are typically 0.2 V pk-pk and 0.2 μs in duration (120-pF load).

ON-OFF TIMING Timing is phase-coherent with, and controlled by, either the signal at the SIGNAL INPUT connector or a different signal applied to the EXT TIMING connector. The on interval (duration of burst) and the off interval (between bursts) can be determined by cycle counting, timing, or direct external control.

Cycle-Count Mode: On and off intervals can be set independently, to be of 1, 2, 4, 8, 16, 32, 64, or 128 cycles (i.e. periods) duration or to be 2, 3, 5, 9, 17, 33, 65, or 129 cycles with +1 switch operated.

Timed Mode: On and off intervals can be set, independently, for durations of 10 μs to 10 s. On and off times occur at first proper phase point of controlling signal occurring after time interval set on controls; one interval can be timed while other is counted.

Switching Phase: In above modes, input controls determine phase of timing signal at which on and off switching occurs. SLOPE control selects either positive or negative slope of timing signal; TRIGGER LEVEL control sets voltage level at which both on and off switching occur.

Direct External Control: A 10-V pulse applied to rear-panel connection will directly control switching.

SYNCHRONIZING PULSE: A dc-coupled pulse that alternates between approx +8 V for output on, and −8 V when off. Source resistance approx 0.8 kΩ for positive output and 2 kΩ for negative.

GENERAL

Power Required: 100 to 125 or 200 to 250 V, 50 to 400 Hz, 16 W.

Accessories Supplied: Power cord.

Mounting: Convertible-Bench Cabinet.

Dimensions (width x height x depth): Bench, 8½ x 5⅝ x 10¼ in. (220 x 145 x 260 mm); rack, 8½ x 5¼ x 8⅝ in. (220 x 135 x 255 mm).

Weight: Net, 8 lb (3.7 kg); shipping, 12 lb (5.5 kg).

Catalog Number	Description
	1396-B Tone-Burst Generator
1396-9702	Bench Model
1396-9703	Rack Model

See *General Radio Experimenter*, May 1964 and March 1966.

NOTE: This instrument is equipped with our new snap-on knob for added convenience and safety. Refer to the Service Section for details.

Condensed Operating Instructions

a. Connect the signal source to the SIGNAL INPUT front- or rear-panel terminals.

b. If the input signal source is to be used for the timing signal source, set the TIMING switch on the rear panel to NORM.

c. If an external timing signal source is desired, connect the source to the rear-panel EXT TIMING connector and set the rear-panel TIMING switch to EXT or EXT DIR as desired.

d. Connect applicable instrument(s) to the SIGNAL OUTPUT terminals on the front or rear panels.

e. Set the Type 1396 front-panel POWER switch to ON.

f. Set the front-panel OUTPUT ON, ON TIME, OUTPUT OFF, OFF TIME, and CYCLE COUNT switches and controls for the desired output.

g. Turn on the input- and output-connected instruments; adjust the signal source for a signal not greater than 10 V pk and not less than 1 V pk-pk; adjust the external-timing-signal source, if used, for the same levels indicated for the signal source.

h. Adjust the TRIGGER LEVEL control to trigger the timing circuits over the range of -10 to +10 V pk. The OUTPUT ON and/or OUTPUT OFF indicator-switch dials should light alternately, provided the unit is not in the CONTinuous mode of operation.

i. Set the SLOPE switch to either - or + for triggering on the negative- or positive-going slope of the timing signal, respectively.

Introduction—Section 1

1.1 GENERAL.

The Type 1396 Tone-Burst Generator (Figure 1-1) operates as a high-quality fast switch that alternately interrupts and passes an input signal, thus chopping into bursts a periodic input signal or a continuous tone applied to the input. The instrument times the burst duration and interval between bursts by counting the number of cycles, or periods, of the input signal, or by actually timing the duration and interval. Panel controls permit these "on" and "off" intervals to be set to a wide range of values. The intervals may be binary multiples of one period of the input signal (1, 2, 4, 8, 16, 32, 64, or 128 cycles) or may be timed from 10 μs to 10 seconds, or both. Consequently, the "off" interval may be timed and the "on" interval counted, or vice versa, if desired.

Tone-burst intervals can also be produced by an external timing signal that can be cycle counted, timed, or can directly turn the output on and off.

In both the cycle counting and timed modes of operation, the phase at which the burst starts and stops can be established in relation to the phase of the input timing or external timing signal. Front-panel switch settings determine the phase of the timing signal that the output will be turned on or off. Thus, the phase that the burst will start and stop can be selected, and the burst will be phase coherent from burst-to-burst.

The count mode can be advanced by one period by the CYCLE COUNT switch on the front panel, providing durations of 2, 3, 5, 9, 17, 33, 65, and 129 cycles. Front-panel controls can also turn on the output continuously or can provide single bursts. The instrument can also operate on nonsinusoidal or aperiodic inputs.

1.2 PURPOSE.

The 1396 fills the gap between steady-state cw testing and step-function, or pulse, testing of amplifiers, meters, etc. The instrument is ideally suited for applications such as the test and calibration of sonar transducers and amplifiers, the measurement of distortion and transient response of amplifiers and loudspeakers, and routine testing of filters and ac meters. Still other uses are found in the measurement of room acoustics and automatic-gain-control circuits, in the synthesis of time ticks on standard-time radio transmission, in psychoacoustic instrumentation, and in numerous other applications. Typical applications are described in Section 4.

1.3 DESCRIPTION.

The Type 1396 is assembled in a metal cabinet ready for bench use. A Rack-Adapter Set (P/N 0480-9723) is available for rack mounting the unit in an EIA standard 19-inch relay rack. The unit includes its own power supply and can operate on 50- to 400-Hz line voltages of 100 to 150 V or 200 to 250 V, selectable at the rear panel. Proper fuses for these voltage ranges (0.2A for the 100- to 150-V range and 0.1A for the 200- to 250-V range) are fitted in fuse holders at the rear panel. In addition, alternate front-panel signal connectors are located on the rear panel for use when rack-mounting the unit, or for other uses. The physical characteristics of the unit are described in the specifications at the front of the manual. Complete dimensions for the bench-mounted unit and associated rack adapter set are given in Section 2.

All the circuits of the 1396 are on two circuit boards. The main circuit board, occupying the lower position in the instrument, contains all the circuits except the binary scaler. The binary scaler is on the upper circuit board. Both circuit boards are hinged to the chassis. When the chassis is removed from the cabinet and placed on its side, both boards can be swung out, providing easy access to the components.

The instrument has an extendible bail between the two front feet which, when pulled down, will allow the instrument to be set in a tilted position on a bench for easy viewing of the front panel.

1.4 CONTROLS AND CONNECTORS.

Figure 1-1 shows the front-panel controls and connectors, and Table 1-1 contains a description of the controls and connectors. Figure 1-2 shows the rear-panel controls and connectors, and Table 1-2 contains a description of the controls and indicators.

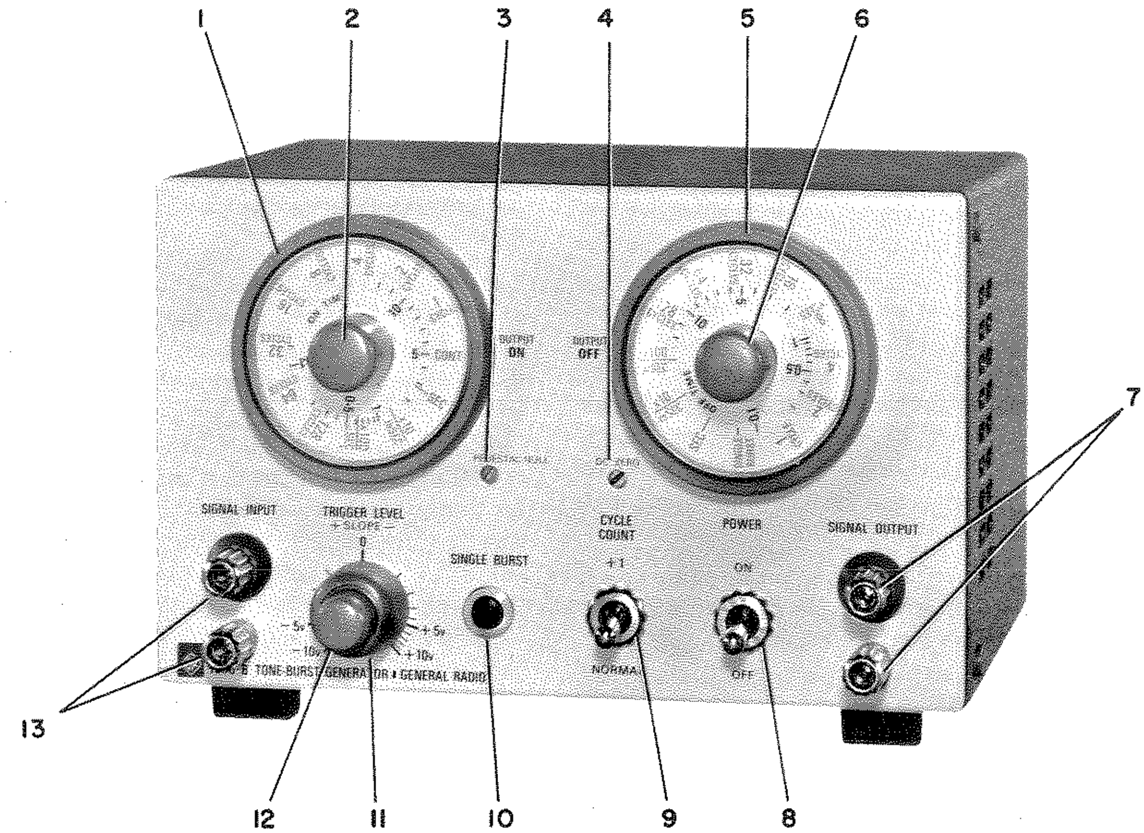


Figure 1-1. Type 1396-B Tone-Burst Generator.

Table 1-1

FRONT-PANEL CONTROLS AND CONNECTORS

Fig. 1-1 Ref. No.	*Name*	*Type*	*Function*
1	OUTPUT ON	Twelve-position rotary indicator-switch.	Sets the time during which the output will occur, or be "on". The first eight positions (1, 2, 4, 8, 16, 32, 64, and 128) set the time in whole cycles (periods) of the signal input by counting the number of cycles of the input signal or an external timing signal. The periods are binary multiples of one period of the input or external timing signals. The CONT position provides a continuous output signal. The SEC, x 10 mSEC, and X100 μSEC positions provide bursts in the one-second, 10-ms and 100 μs ranges. These switch positions are used in conjunction with the ON TIME control to provide output "on" intervals from 10 μs to 10 s. The dial lights when an output signal occurs.
2	ON TIME	Dial with graduations from 0.1 to 10.	Sets the "on" intervals in the time mode for durations of 10 μs to 10 s when used in conjunction with the OUTPUT ON indicator-switch.
3	PEDESTAL NULL	Screwdriver adjustment.	Allows any dc difference in output voltage between the output on and off intervals to be nulled out. The pedestal voltage is generated internally and is insignificant in amplitude for all but the lowest signal levels.
4	DC ZERO	Screwdriver adjustment.	Establishes the output dc level at zero volts by inserting a small controlled voltage offset between the input and output which "bucks" any offset produced by other circuitry or by the PEDESTAL NULL control.
5	OUTPUT OFF	Twelve-position rotary indicator-switch.	Sets the time during which the output will be "off". The first 11 positions (1, 2, 4, 8, 16, 32, 64, 128, X 100 μSEC, X 10 mSEC, and SEC) set the "off" interval in the same manner the OUTPUT ON switch sets the "on" interval. The SINGLE BURST position is used in conjunction with the SINGLE BURST pushbutton switch. When set to this position, and the SINGLE BURST pushbutton switch is pressed, a single burst of a duration determined by any setting of the OUTPUT ON switch (except the CONT

Table 1-1 (Cont'd)

FRONT-PANEL CONTROLS AND CONNECTORS

Fig. 1-1 Ref. No.	*Name*	*Type*	*Function*
5	OUTPUT OFF (Continued)	Twelve-position rotary indicator-switch.	position, which should not be used in this mode of operation) will occur. The dial lights when the output is "off"
6	OFF TIME	Dial with graduations from 0.1 to 10.	Sets the "off" interval in the time mode for durations of from 10 μs to 10 s when used in conjunction with the OUTPUT OFF indicator-switch.
7	SIGNAL OUTPUT	Jack-top binding-post pair.	Provides the tone-burst output of the switched signal via a unity gain output amplifier with approximately at 25 -Ω output impedance, increasing above 0.2 MHz. The lower terminal is connected to the chassis and, via the power cord, to ground.
8	POWER	Toggle switch, DPST.	When set to ON, applies line power to the unit.
9	CYCLE COUNT	Toggle switch, DPDT.	When set to NORMAL, the instrument counts timing-signal pulses in the binary periods determined by the settings of the OUTPUT ON and OUTPUT OFF switches. When set to +1 the cycles (periods) indicated on the OUTPUT ON and OFF switches are increased by one. Thus, the indicator output on and off intervals can be set to 2, 3, 5, 9, 17, 33, 65, and 129 cycles of the input or external timing signals.
10	SINGLE BURST	Pushbutton switch.	Used in conjunction with the OUTPUT OFF switch. When the OUTPUT OFF switch is set to SINGLE BURST and the SINGLE BURST pushbutton switch is pressed, the output is a single burst of a duration determined by the setting of the OUTPUT ON indicator-switch.
11	TRIGGER LEVEL	Rotary switch.	Sets the voltage level (-10 V to +10 V) of the input timing signal or external timing signal at which a trigger pulse will occur for application to the counting and timing circuits and, therefore, the phase of which the tone-burst starts and stops.

Table 1-1 (Cont'd)

FRONT-PANEL CONTROLS AND CONNECTORS

Fig. 1-1 Ref. No.	*Name*	*Type*	*Function*
12	SLOPE	Two-position rotary switch.	When set to plus (+), the positive-going slope of the input timing or external timing trigger pulse will turn the output on and off. When set to minus (-), the negative-going slope of the input timing or external timing trigger pulse will turn the output on and off.
13	SIGNAL INPUT	Jack-top binding-post pair.	Input for the signal to be switched. Input impedance is approximately 50 kΩ. The lower terminal is connected to the chassis and, via the power cord, to ground.

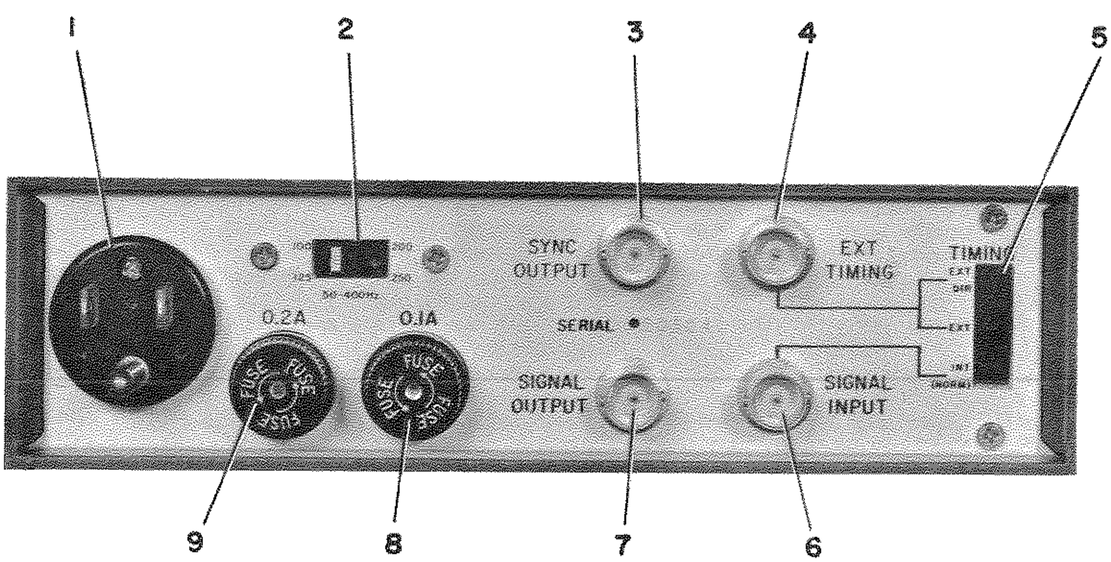


Figure 1-2. Rear-panel Controls and Connectors.

Table 1-2

REAR-PANEL CONTROLS AND CONNECTORS

Fig. 1-2 Ref. No.	*Name*	*Type*	*Function*
1	PL801	Three-wire power-plug receptacle.	Connection for 100- to 125-V or 200- to 250-V, 50- to 400-Hz line voltage.
2	100-125, 200-250, 50-400 Hz	Two-position slide switch.	When set to 100-125, the instrument will operate on 100- to 125-V line voltage. When set to 200-250, the instrument will operate on 200-250-V line voltage.
3	SYNC OUTPUT	BNC connector, coaxial.	Output for a synchronizing signal which goes from +8V, when the output is on, to -8V when the output is off.
4	EXT TIMING	BNC connector, coaxial.	Input for a 10-V pulse that will directly control burst durations in lieu of input signal control. Input impedance is approximately 20 kΩ.
5	TIMING	Three-position switch.	When set to INT (NORM), control of burst durations is obtained from the input signal. When set to EXT, control is obtained from an external timing source when the source is connected to EXT TIMING connector. When set to either of these positions, however, operation is still dependent on the setting of the OUTPUT ON and OFF indicator-switches. When set to EXT DIR, the external timing signal directly controls the output of the instrument, establishing the output on and output off intervals.
6	SIGNAL INPUT	BNC connector, coaxial.	Alternate input signal connection for rack-mount unit or when a rear input connection is desired. The connector is in parallel with the front-panel SIGNAL INPUT binding-post pair.
7	SIGNAL OUTPUT	BNC connector, coaxial.	Alternate output signal connection for rack-mount unit or when a rear output connection is desired. The connector is in parallel with the front-panel SIGNAL OUTPUT binding-post pair.
8	0.1 A	Extraction-post fuse holder.	Holds 0.1-A, 200-250-V line-voltage slo-blo fuse.
9	0.2 A	Extraction-post fuse holder.	Holds 0.2-A, 100-125-V line-voltage slo-blo fuse.

The bottom terminal of binding-post pairs are connected to the instrument chassis and, via the power cord, to ground. All signals are dc coupled.

1.5 ACCESSORIES SUPPLIED.

The following accessories are supplied with the 1396:

Power Cable, P/N 4200-9622

Two slo-blo fuses, Bussman Mfg., MDL 0.1A and MDL 0.2A

1.6 ACCESSORIES AVAILABLE.

Table 1-3 lists the accessories available. Since the Type 1396 can be used in a wide variety of applications, Table 1-3 contains only a partial listing of the available accessories. The accessories listed are those which are used in the more common applications. Consult a GR catalog for a description of other available instruments.

Table 1-3
ACCESSORIES AVAILABLE

Name and GR Type or Part No.	Application
Rack Adaptor Set, P/N 0480-9723	Rack-mounting instrument.
Type 1308 Audio Oscillator and Power Amplifier (20 Hz to 20 kHz in 3 ranges, 200-VA, 400 V in 5 ranges, or 5 A in 6 ranges output)	Signal source or amplifier with high-power capability.
Type 1310 Oscillator (2 Hz to 2 MHz in 6 decade ranges, up to 20 V output)	General-purpose signal source.
Type 1311 Audio Oscillator (50 Hz to 10 kHz in 11 fixed frequencies, continuously adjustable output voltage to 100 V in 5 ranges)	Signal source with discrete frequencies.
Type 1312 Decade Oscillator (10 Hz to 1 MHz in 5 decade ranges, up to 20 V output)	Signal source with decade controls and in-line readout for fast, accurate operation.
Type 1313 Oscillator (10 Hz to 50 kHz in one range, up to 5 V output)	Sine- or square-wave signal source that can be manually swept.
Type 1346 Audio-Frequency Microvolter (dc to 100 kHz)	Low-distortion attenuator.

1.7 AVAILABLE PATCH CORDS AND ADAPTORS.

The front-panel SIGNAL INPUT and SIGNAL OUTPUT connectors are standard 3/4-inch-spaced pairs of jacktop binding posts that accept banana plugs, standard telephone tips, alligator clips, crocodile clips, spade terminals, and all wire sizes up to number 11. (See Figure 1-3.)

The rear-panel SYNC OUTPUT, SIGNAL OUTPUT, EXT TIMING, and SIGNAL INPUT connectors are BNC jacks. A wide variety of GR patch cords is available, as well as a comprehensive selection of adaptors (Table 1-4) to convert the terminals for use with most commercial and military coaxial connectors. Shielded patch cords are recommended for input and output connections.

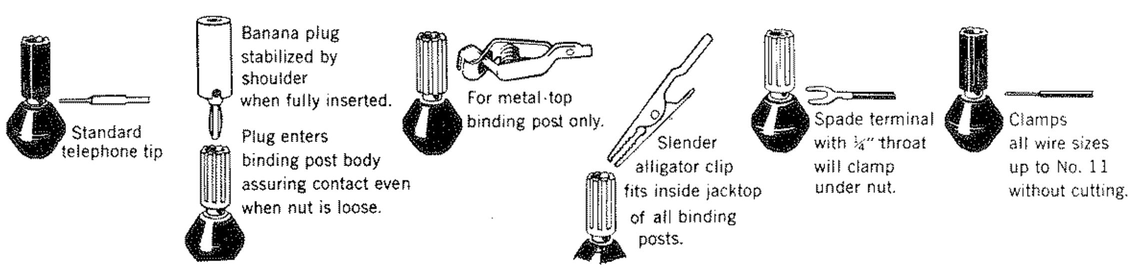
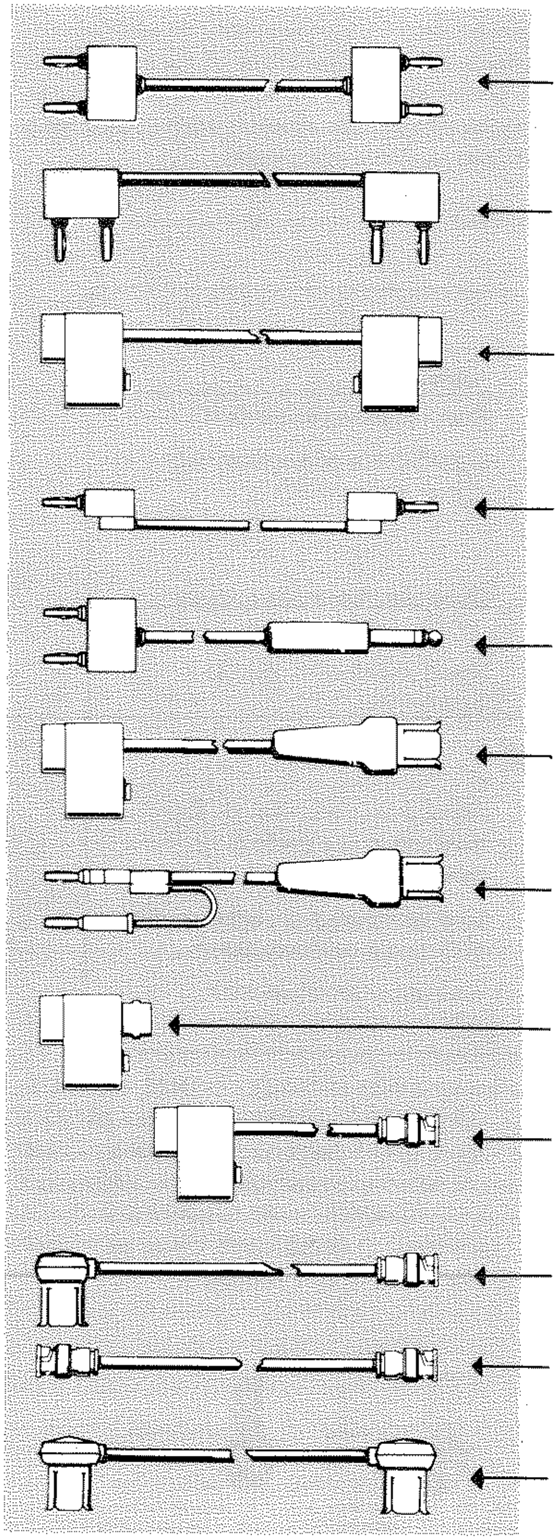


Figure 1-3. Methods of connection to the binding-post terminals.

Table 1-4
AVAILABLE GR PATCH CORDS



TYPE NO.	DESCRIPTION	CATALOG NO.
274-NQ	Double-plug patch cord, in-line cord, 36" long	0274-9860
274-NQM	Double-plug patch cord, in-line cord, 24" long	0274-9896
274-NQS	Double-plug patch cord, in-line cord, 12" long	0274-9861
274-NP	Double-plug patch cord, right-angle cord, 36" long	0274-9880
274-NPM	Double-plug patch cord, right-angle cord, 24" long	0274-9892
274-NPS	Double-plug patch cord, right-angle cord, 12" long	0274-9852
274-NL	Shielded double-plug patch cord, 36" long	0274-9883
274-NLM	Shielded double-plug patch cord, 24" long	0274-9882
274-NLS	Shielded double-plug patch cord, 12" long	0274-9862
274-LLB	Single-plug patch cord, black, 36" long	0274-9468
274-LLR	Single-plug patch cord, red, 36" long	0274-9492
274-LMB	Single-plug patch cord, black, 24" long	0274-9847
274-LMR	Single-plug patch cord, red, 24" long	0274-9848
274-LSB	Single-plug patch cord, black, 12" long	0274-9849
274-LSR	Single-plug patch cord, red, 12" long	0274-9850
1560-P95	Adaptor cable, double-plug to telephone plug, 36"	1560-9695
874-R34	Coaxial patch cord, double plug to GR874, 36" long	0874-9692
874-R33	Coaxial patch cord, two plugs to GR874, 36" long	0874-9690
274-QBJ	Adaptor, shielded double plug to BNC jack	0274-9884
776-A	Patch cord, shielded double plug to BNC plug, 36" long	0776-9701
776-B	Patch cord, GR874 (right-angle) to BNC plug, 36" long	0776-9702
776-C	Patch cord, BNC plug to BNC plug, 36" long	0776-9703
776-D	GR874 to GR874, both right-angle, 36" long	0776-9704

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Installation–Section 2

2.1 INSTRUMENT LOCATION.

Locate the instrument so vent holes on the sides and back are unrestricted. Although unrestricted airflow is desirable, no damage will result to the instrument if the air vents are obstructed. Ambient air temperature should be over 0° C (32° F) and less than 55° C (131° F).

2.2 DIMENSIONS.

Figure 2-1 is an outline drawing of the Type 1396 in bench and rack configurations showing their overall dimensions.

2.3 ELECTRICAL CONNECTIONS.

The 1396 operates on 50- to 400-Hz line voltages of either 100 to 125 V or 200 to 250 V, depending on the setting of the two-position line-voltage switch on the rear panel.

Set the line-voltage switch to the appropriate line voltage provided, using a narrow-blade screwdriver, and connect the three-wire power cord to the line and three-terminal male connector at the rear panel.

2.4 BENCH MOUNTING.

To set the instrument in a tilted position, pull the bail between the front feet down as far as possible.

2.5 RACK MOUNTING.

With Rack Adaptor Set, P/N 0480-9723, the 1396 can be rack mounted. Table 2-1 lists the parts included in the Rack Adaptor Set. Mount the instrument as follows (See Figure 2-2.):

a. Loosen the two captive 10/32 screws in the rear of the cabinet until the chassis is free; slide the chassis forward, out of the cabinet.

b. Remove the four rubber feet from the cabinet. Simply push out the two rear feet. Spread the bail (A, Figure 2-2) slightly and the two front feet (B) and the bail will drop out. Be sure to save all parts as they are removed for possible reconversion of the instrument to bench mounting.

c. Pierce and push out the plugs from the four bosses (C) on the inner sides of the cabinet, near the front.

d. Press the subpanel (D) into the blank panel (E) to form a support liner for the latter.

e. Attach the short flange of the blank panel to the front of the cabinet (on either side of the cabinet, as desired) using two 5/16-in. screws (F). Note that the screws enter in opposite directions – one from inside the cabinet and one from the flange side, as shown.

f. Pierce and push out the plug in the rear boss (G) *on the side toward the blank panel only*, as shown.

g. Attach one end of the support bracket (H) to the lower rear boss. The bracket must be placed so that the screw passes through a clearance hole into a tapped hole.

h. Attach the other end of the support bracket to the lower rear hole in the wide flange, as shown, using a 5/16-in. screw (K).

i. Attach one Rack Adaptor Assembly (handle) to the side of the cabinet opposite the blank panel, using two 5/16-in. screws (L). Again note that the screws enter in opposite directions, one from inside the cabinet and one from outside. Use the upper and lower holes in the assembly.

j. Attach the other Rack Adaptor Assembly (handle) to the wide flange on liner (D) and the flange on the blank panel (E). Use two 5/16-in. screws (M) through the two flange holes nearest the panel and through the upper and lower holes in the handle. Again, the screws enter in the opposite directions.

k. Install the instrument in the cabinet and lock it in place with the two captive screws in the rear that were loosened in step a.

l. Place a straight edge across both the instrument panel and the blank panel. Loosen the screw (J) *through the slot* in the support bracket (H). Exert a slight pressure on the blank panel (E) so that it forms a straight line with the instrument panel, and tighten the screw (J) in the bracket to lock the panels in this position.

m. Slide the entire assembly into the relay rack and lock it in place with the four 9/16-in. screws (N) with captive nylon cup washers. Use two screws on each side and tighten them by inserting a screwdriver through the holes (P) in the handles.

2.6 RECONVERSION TO BENCH MOUNTING.

a. To reconvert the instrument for bench use reverse the procedures of paragraph 2.5, first removing the entire assembly of instrument, cabinet, and blank panel from the rack.

b. Remove:

1. Chassis from the cabinet.
2. Support bracket (H) from the cabinet.
3. Blank panel (with handle attached) from one side of the cabinet.
4. Rack Adaptor Set (handle) from the other side of the cabinet.

c. Push the two rear feet into the cabinet, and slide the bail (A) and two front feet (B) into place. Install the instrument in its cabinet and lock it in place with the two captive screws through the rear panel.

2.7 RACK-MOUNTING TWO INSTRUMENTS.

Two instruments of the same panel size can be mounted side-by-side in an E1A standard 19-in. relay rack. Use the procedure of paragraph 2.5, substituting the second instrument for the blank panel. Do not use the support bracket (H, Figure 2-2), but insert three screws through the bosses in the adjacent sides of the cabinet, two near the front (C) and one near the rear (G). The four feet and the bail must, of course, be removed from each cabinet. Use the four screws (N) with nylon washers to lock the instruments in the rack. The required hardware is:

1. Three screws, BH 10-32, 5/16-in. P/N 7080-0800.

2. Four screws, BH 10-32, 9/16-in. with nylon washers, P/N 7270-6310.

Table 2-1

RACK-ADAPTOR SET, P/N 0480-9723

Quantity	Description	Fig. 2-2 Ref.	Part Number
1	Blank Panel	E	0480-8933
1	Sub Panel	D	0480-8953
2	Rack-Adaptor Assembly	Q	0480-4903
1	Support Bracket	H	0480-8524
1	Hardware Set, (includes the following parts):	—	0480-3080
8	Screw, BH, No. 10-32, 5/16 in.	F,J,K,L,M	———
4	Screw, BH, No. 10-32, 9/16 in., with nylon-cup washers	N	———

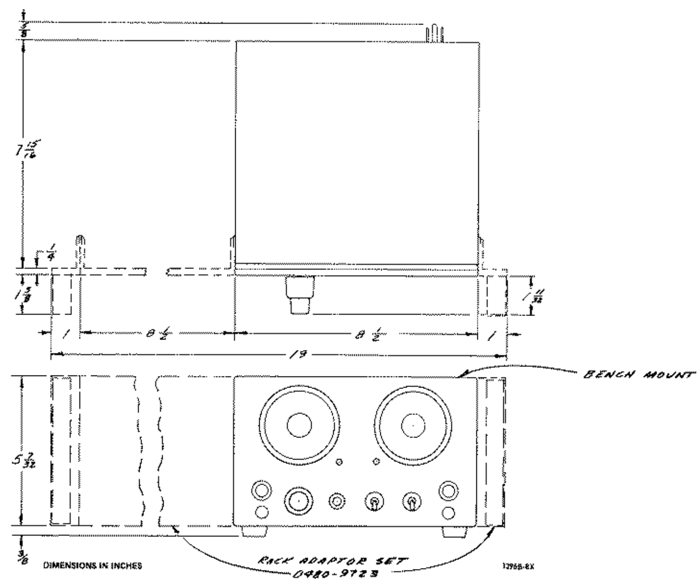


Figure 2-1. Approximate dimensions of 1396 bench and rack-mount units.

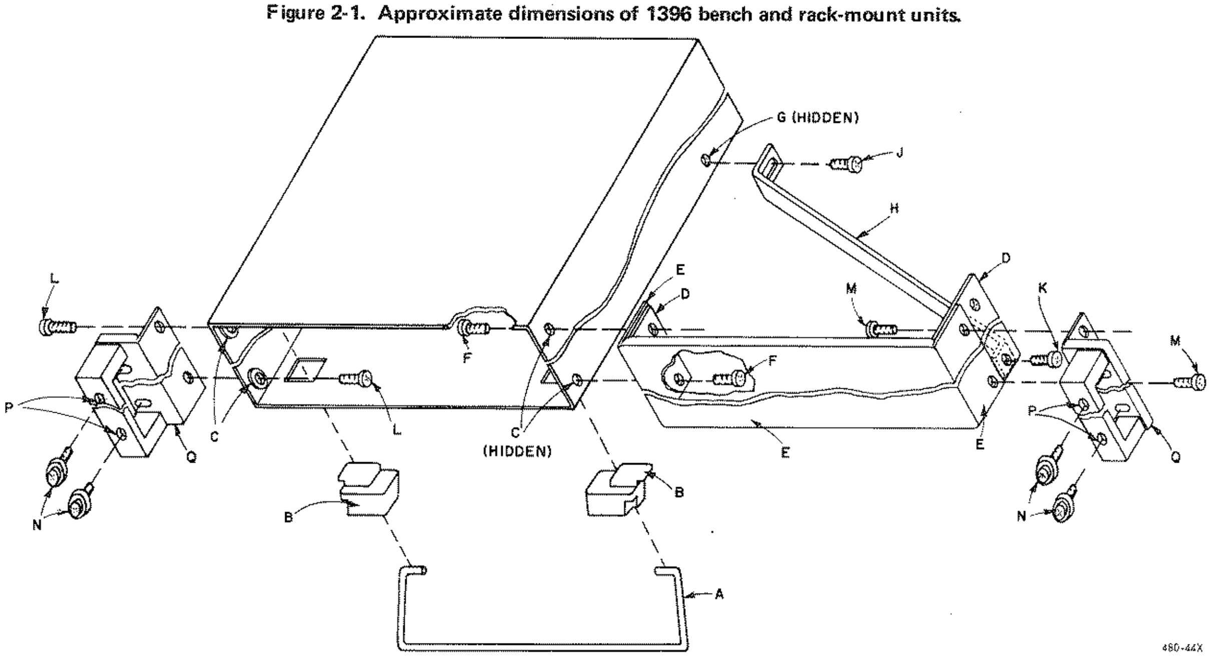


Figure 2-2. Assembly of the 1396 for installation in a relay rack.

Operation—Section 3

3.1 NORMAL OPERATION.

Perform the following steps to set the instrument into normal operation:

a. Check that the POWER switch is set to OFF.

b. Set the line-voltage slide switch on the rear panel to the position corresponding to the line voltage. Use a narrow-blade screwdriver to slide the switch.

c. Connect the supplied power cord to the line voltage source and to the 3-pin line-voltage connector on the rear panel.

d. Connect a GR Type 1310 Oscillator (2 Hz - 2 MHz), or equivalent, to the SIGNAL INPUT connectors on either the front or rear panels. A shielded patch cord (GR247-NL) is recommended for all connections to the instrument, if applicable. Paragraph 1.7 contains a listing of other recommended GR patch cords. All binding-post pairs on the instrument are connected to the chassis and, via the power cord, to ground.

e. Connect the applicable instrument(s) to the SIGNAL OUTPUT terminals on either the front or rear panels.

f. If the input signal source is to trigger the burst on and off, set the TIMING switch on the rear panel to INT (NORM).

g. If an external timing signal is to trigger the burst on and off, connect the external timing signal source to the EXT TIMING connector on the rear panel. Set the TIMING switch to EXT if it is desired to substitute the external timing signal for the input timing signal and otherwise operate normally, or to EXT DIR if it is desired to trigger the bursts on and off directly with the external timing signal. Adjust the external timing signal source for not more than 10 V pk and not less than 1 V pk-pk to operate the 1396 properly.

h. Set the OUTPUT ON, ON TIME, OUTPUT OFF, OFF TIME, and CYCLE COUNT switches and controls to produce the desired output on and off intervals. Refer to Table 1-1, if necessary, for a description of these switches and controls. The on interval can be cycle counted and the off interval timed, or vice versa, if desired.

i. Set the POWER switch to ON.

j. If possible at this time, adjust the signal source to an output not exceeding 10 V pk, and not less than 1 V pk-pk, and turn on the signal source and other instrument(s). The signal source level can be adjusted after turn on, if necessary; no damage will result to the 1396.

k. Adjust the TRIGGER LEVEL and SLOPE controls. The TRIGGER LEVEL can shift the trigger level over the range of -10 to +10 V pk. The instrument will trigger (activate) properly when the trigger level is adjusted within the voltage range of the input signal (maximum 10 V pk; minimum 1 V pk-pk). The OUTPUT ON and OUTPUT OFF indicator-switch dials will light alternately, provided the 1396 is not operating in the CONTinuous mode.

3.2 OSCILLOSCOPE SYNCHRONIZATION.

An oscilloscope may be difficult to trigger on a tone-burst signal, particularly when the input frequency is changed. The rear-panel SYNC OUTPUT connector provides a synchronizing pulse to assist in triggering. Set the oscilloscope triggering for the dc mode, positive slope, and 0 level. Apply the synchronizing pulse to the trigger input terminals of the oscilloscope; the trace will start when the output is "on." To start the trace as the output goes "off," set the oscilloscope to negative slope.

An oscilloscope with a bandwidth of 20 MHz or greater, such as a Tektronix Type 543 B, 544, or 454 with a suitable plug-in unit, where required, can be used for monitoring the input and output signals.

3.3 CONTINUOUS OPERATION.

To hold the output on continuously, set the OUTPUT ON indicator switch to CONT. This interrupts the normal operation of the instrument, not allowing the output to turn off. When the output is on continuously, the synchronization signal is interrupted; therefore, the synchronization mode of the oscilloscope must be changed.

3.4 SINGLE-BURST OPERATION.

To provide a single tone burst:

a. Set the OUTPUT ON switch to the desired burst duration. Do not set the switch to CONT.

b. Set the OUTPUT OFF switch to SINGLE BURST and press the SINGLE BURST pushbutton switch.

3.5 OPERATION WITHOUT A TIMING SIGNAL.

The instrument can be operated without a timing-signal input. With *no* external timing signal applied, set the rear-panel TIMING switch to EXT or EXT DIR. Cycle the SLOPE switch from + to - and back. Each cycle of the SLOPE switch produces the equivalent of one cycle of the timing signal.

3.6 TIMED-MODE FEATURE.

Set the OUTPUT OFF or OUTPUT ON indicator-switches to either SEC, x10 mSEC, or x100μSEC and advance the OFF TIME or ON TIME controls smoothly, to change the output off or on times in units of one period. Even when the off or on intervals are under time-mode control, the phase-coherency feature of the instrument keeps the phase of the tone-burst coherent from burst-to-burst.

Applications – Section 4

4.1 GENERAL.

The Tone-Burst Generator uniquely provides an instrumentation bridge in the gap between continuous-wave testing and step-function, or pulse, testing. The Type 1396 finds diverse applications, from sonar-transducer calibration to the generation of controlled periodic line transients. A few of the applications are described in the following paragraphs. The examples generally assume that the 1396 operates on a sinewave; however, it can operate on any periodic waveform.

One of the useful features of the instrument is that the output signal is coherent, that is, the on-off switch circuit opens and closes at the same point in the signal voltage cycle for each tone burst. Coherence is of value for two reasons: first, the coherent tone burst is much more easily observed or analyzed by oscillographic or sampling methods; second, the frequency content of a tone burst depends upon the phase of the switching action compared to the signal, as explained in paragraph 4.2. If the signals are not coherent, the phase, and hence the frequency content, is drifting, and test results are less reproducible or less clear than with a coherent tone burst.

Another useful feature is the control of the number of cycles in the tone burst, which allows the production of tone bursts with consistent and controllable frequency content.

4.2 FREQUENCY CONTENT OF TONE BURSTS.

Applications frequently demand some knowledge of the frequency components of a tone burst of a sinusoidal signal. In general, the output voltages can be written as a Fourier series having only sine or cosine terms as follows:

$$e(t) = \sum_{n=1}^{\infty} a_n \begin{Bmatrix} \sin \\ \cos \end{Bmatrix} \left[\frac{2\pi n t}{(N+M)\,T} \right]$$

where:

$e(t)$ = the tone-burst voltage.

a_n = the amplitude of the nth component.

n = harmonic number (1, 2, 3, 4, etc.).

N = number of cycles of signal in the burst (output-on count in the Tone-Burst Generator).

M = number of cycles (periods) of signal between bursts (output-off count in the Tone-Burst Generator).

T = the period of the signal being switched.

The sine series is used if the signal is switched on and off at zero crossings, and the cosine series is used if switching occurs at the peak point of the sinusoidal input voltage. The equation indicates that a tone burst is equivalent to a signal of amplitude a_1 at the repetition rate of the tone burst, plus a signal of amplitude a_2 at twice the repetition rate (the second harmonic), plus a signal of amplitude a_3 at three times the repetition frequency (the third harmonic), and so on, indefinitely. The amplitude of each component in the above series can be obtained from the following equation:

$$a_n = \underbrace{E\frac{N}{N+M}}_{\text{SCALE FACTOR}} \left[\underbrace{\frac{\sin x}{x}}_{\text{MAIN PART}} \mp \underbrace{\frac{\sin y}{y}}_{\text{PHASE CORRECTION}} \right]$$

where:

$$x = 2N\left(\frac{n}{N+M} - 1\right)\frac{\pi}{2}$$

$$y = 2N\left(\frac{n}{N+M} + 1\right)\frac{\pi}{2}$$

E = the amplitude of the signal being switched.

As shown above, the expression for a_n can be broken into three parts: (1) scale factor, (2) main part, and (3) phase correction.

The scale factor is the product of the amplitude of the sinusoidal signal, E, times a duty-ratio factor, N/N + M. The duty-ratio factor approaches 0 for widely spaced, narrow bursts, or 1 for closely spaced, wide bursts.

The main part of the spectrum (see Figure 4-1) is the familiar sin x/x function, which is centered at the sinsoidal frequency, f, and has zeros and nodes at intervals of f/N about f.

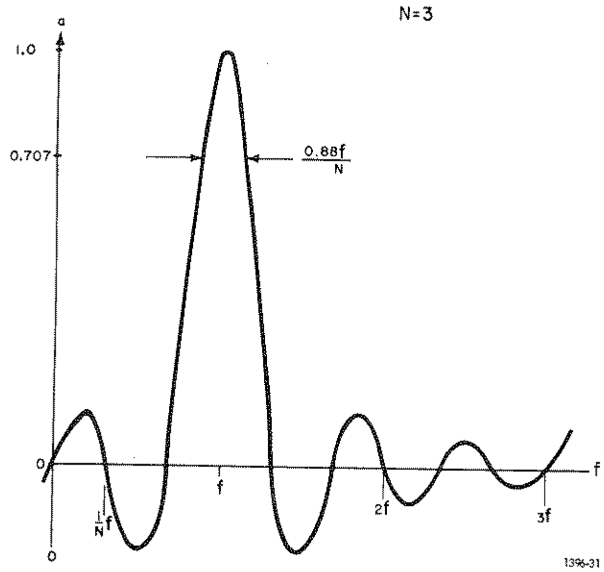


Figure 4-1. The main part of the envelope of spectrum of a tone burst (N=3).

The phase correction (see Figure 4-2) sin y/y function is subtracted for sine tone bursts or added for

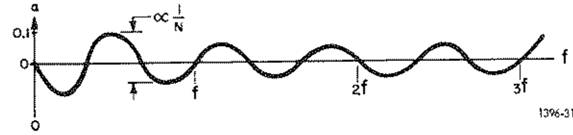
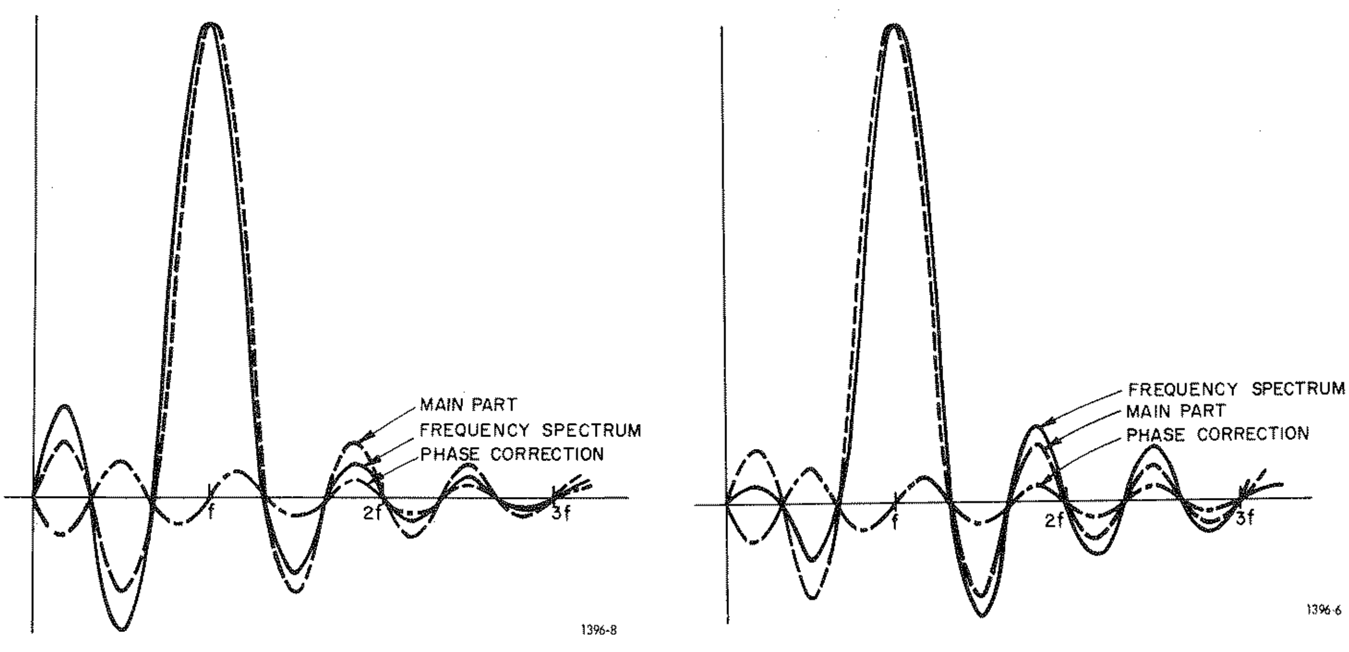


Figure 4-2. The phase correction portion of the envelope of the spectrum of a tone burst (N=3).

cosine tone bursts. The phase correction does not affect the maximum value or the frequency of the nodal values. It does, however, make the spectrum envelope asymmetrical about f. (See Figure 4-3.)

As the number of cycles in the burst, N, changes, the frequency spectrum of the burst changes. Figure 4-4 shows the frequency content for bursts of a signal with frequency, f, for several values of N. The functions for $N = 3$ are also shown in Figures 4-1 and 4-2.

The 3-dB bandwidth of the main lobe of the envelope is $0.88f/N$. (See Figure 4-1.) The amplitude of the Fourier component nearest this 3-dB point changes as the phase of the tone burst changes from sine to cosine. The magnitude of this phase correction is inversely proportional to the number of cycles in the burst. Thus, for a burst of many cycles, the amplitude change in the Fourier component at the 3-dB point is very small as the phase of the tone burst is changed. (Note that in Figure 4-4 the amplitude of the



Phase correction subtracted from the main part.

Phase correction added to the main part.

Figure 4-3. Spectrum of a 3-cycle cosine burst.

phase correction is much greater for a 1-cycle burst than for a 3-cycle burst.)

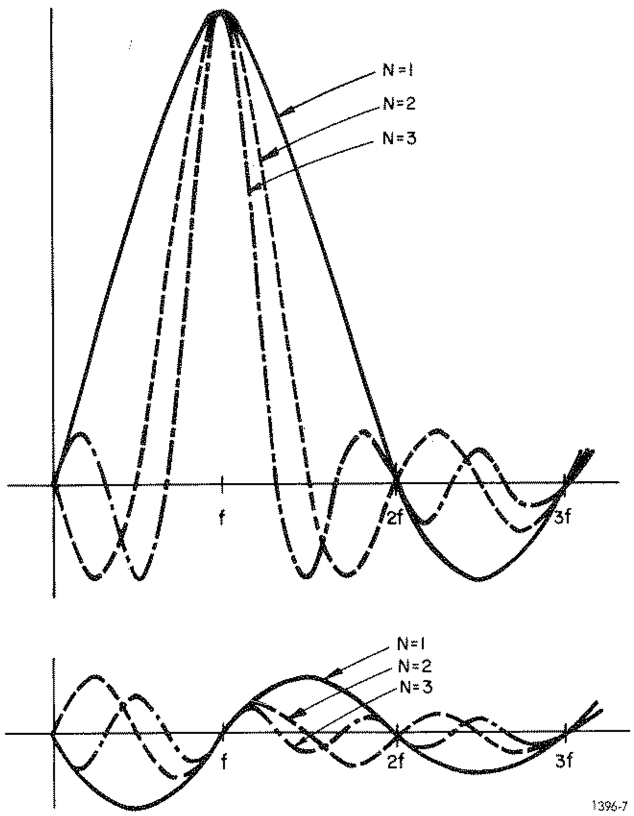


Figure 4-4. Frequency content of tone bursts of 1,2,3, and 4 cycles of a signal of frequency *f*.

Table 4-1 gives the total change in amplitude of the component nearest the 3-dB envelope amplitude point as the phase of the tone burst changes from sine to cosine. If the phase of the tone burst is shifted midway between sine and cosine (45°), the phase correction will no longer disturb the symmetry of the envelope about *f*.

Table 4-1

TOTAL CHANGE OF COMPONENT AMPLITUDE IF BURST CHANGES FROM SINE TO COSINE

N	1	2	3	4	8	16	32
Change	50%	20%	15%	9%	5%	2%	1%

The following application of the expression for a_n shows how a variation in the phase of the tone burst can cause up to a 50% shift in the large-amplitude components of a short tone burst, and a smaller, though significant, shift in the amplitude components of a longer tone burst.

To find the values of a_n in the equation, the values of N and M indicated by the controls on the Tone-Burst Generator are applied and the expression for values of n evaluated. Some care must be exercised when x or y equals zero since the two fractions assume indeterminate forms. The proper value of the fraction under these conditions is 1.

As an example of this analysis, consider a tone burst signal that has one cycle on and one cycle off, or M = N = 1. For this case, the amplitude equation becomes:

$$a_n = E\left[\frac{\sin(n-2)\frac{\pi}{2}}{(n-2)\frac{\pi}{2}} \mp \frac{\sin(n+2)\frac{\pi}{2}}{(n+2)\frac{\pi}{2}}\right]$$

The two fractions in the bracketed expression are subtracted if the TRIGGER LEVEL control is adjusted so that the on-off switch circuit opens and closes at zero crossings of the input signal, and the terms are added if the control is adjusted for switching at the peak voltage point of the waveform. Table 4-2 gives the results of the amplitude equation for values of n equal to 1, 2, 3, 4, and 5, for both zero-crossing and peak-point switching.

Table 4-2

RESULTS OF AMPLITUDE EQUATION FOR VALUES OF n = 1, 2, 3, 4, and 5.

n	a_n for Zero-Crossing Gating	a_n for Peak-Point Gating
1	0.424 E	0.212 E
2	0.500 E	0.500 E
3	0.255 E	0.382 E
4	0	0
5	0.061 E	0.152 E

Figure 4-5 is a plot of the first 31 harmonics of the above signal. The solid areas in the figure represent the components for zero-crossing switching, the lined areas are

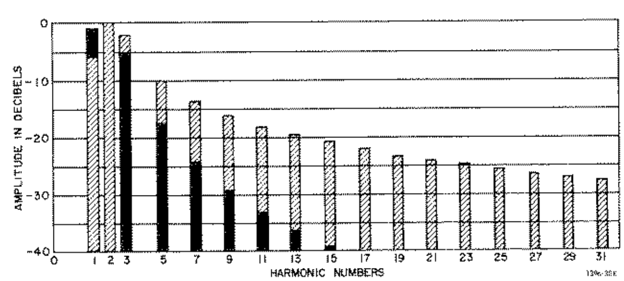


Figure 4-5. The first 31 harmonics of a tone-burst signal with one cycle on and one cycle off.

for peak-point switching. In Figure 4-6, the first 31 harmonics of a second example are plotted. The solid areas in the figure represent the components for zero-crossing switching, the lined areas are for peak-point switching. In this example the tone burst has eight cycles on and eight cycles off. Both curves were taken from an automatic plot of the frequency spectrum produced by a GR Type 1900 Wave Analyzer and a Type 1521 Graphic-Level Recorder. In both examples, the tone burst had N = M so that values of a_n are zero for even values of n (except zero). Therefore, when a tone burst is "square", or has equal on and off times, none of the even harmonics (except the one at the input-signal frequency) are present.

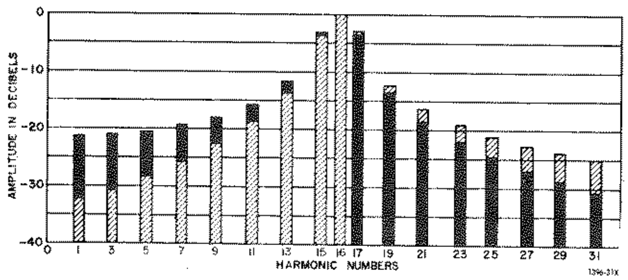


Figure 4-6. The first 31 harmonics of a tone-burst signal with eight cycles on and eight cycles off.

The spectra presented in Figures 4-5 and 4-6 indicate clearly the change in harmonic content as the phase of the switching is changed. The spectra change smoothly between the extreme values as the phase is changed from zero-crossing to peak-point switching. Such a change increases the amplitude of the high-frequency components and diminshes the amplitude of the low-frequency components. For this reason the 1396 has the phase-coherency feature to produce consistent spectra. If bursts are not coherent each burst will have a different phase or at least will drift slowly between sine and cosine bursts, causing a corresponding drift in the spectrum because of the phase-correction properties of the spectrum.

The tone-burst spectrum has the bandwidth properties of a pulse yet the spectrum can be tuned to center at any test frequency just as a continuous tone can. The bandwidth of the tone burst can be adjusted from very wide, impulse-type signal (one-cycle burst) to very narrow (burst of many cycles). Also, because the tone-burst combines some of the useful features of a pulse and the continuous sinusoidal tone, the tone burst can be used in many areas where the other two signals are used. The burst can be particularly effective where the application lies in the wide midground between pulse and sinewave testing

4.3 TESTING IN THE PRESENCE OF REFLECTIONS.

4.3.1 Tone Bursts for Narrow-Band Applications.

When making tests of auditoriums and concert halls, acoustical engineers often must separate, identify, and measure room resonances that may be quite close together in frequency. For these tests a filtered tone-burst with very low spectral content can be helpful. Figure 4-7 shows an unfiltered sinusoidal tone-burst and its corresponding spectral distribution. This 2.0-kHz sinewave is switched on for seven cycles and switched off for 32 cycles. Figure 4-8 shows the same signal after it has passed through a one-third-octave filter. Note the reduced spectral content, which permits greater resolution in searches of closely spaced resonant frequencies. The burst nature of the original signal is preserved to allow observation of the echo signal for reverberation-time measurements. This feature is also useful in other applications where a tone burst of a few cycles is required to take advantage of radar-like phenomena, and at the same time to narrow the bandwidth to take advantage of the sinusoidal properties of a burst.

4.3.2 Transducer Testing.

It is often necessary to test transducers in an environment that produces reflections, such as a reflection tank for testing sonar transducers or an echo chamber for testing speakers or microphones. With continuous-wave testing, the reflections can complicate measurements or introduce errors. Errors in frequency and phase curves are caused by the addition of reflected signals to increase or diminish the direct response. Such errors introduce familiar standing-wave patterns in the response curves.

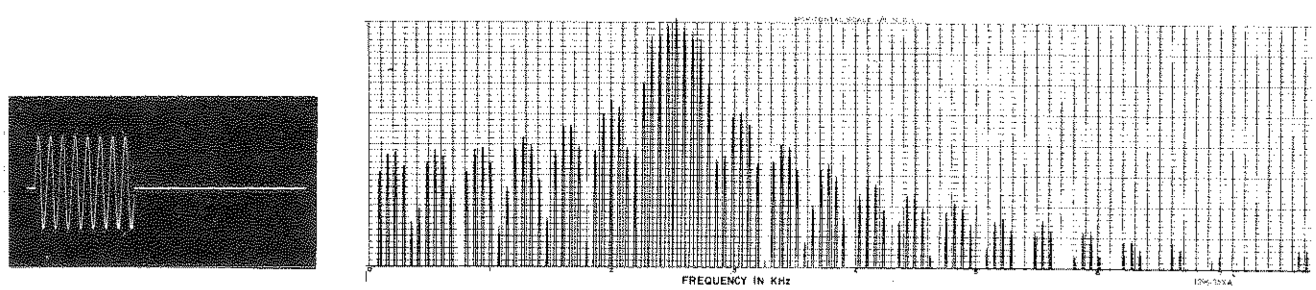


Figure 4-7. Unfiltered sinusoidal tone burst and corresponding spectral distribution.

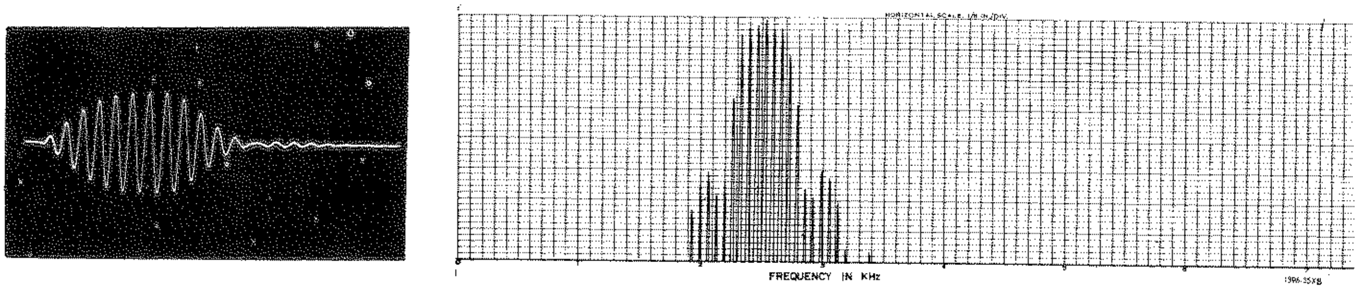


Figure 4-8. Filtered sinusoidal tone burst, one-third-octave filter, and corresponding spectral distribution.

With a tone-burst test signal energizing the transducer, the direct response and the reflected response can be separated by observation of the response as a function of time. As an example, two 1-in.-diameter speakers were mounted in one end of an 8-ft. tube with the opposite end closed. Figure 4-9 shows the voltage waveforms observed across one speaker when the other speaker was driven with tone bursts of 2.95 kHz (left side) and 3.0 kHz (right side) respectively. Note the large pulse at the left which was the direct transmission from one speaker to the other. Its constant amplitude indicates that the frequency response was the same at both frequencies. The middle and right-hand pulses were the first and second reflections from the far end of the tube.

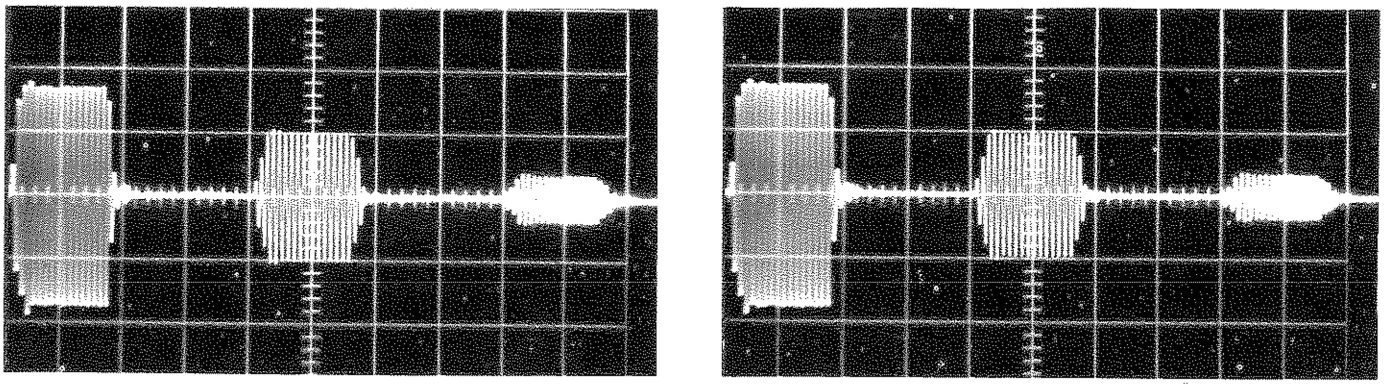


Figure 4-9. Waveforms received by one of two transducers mounted in the end of a closed tube, when the other transducer is driven by a tone burst of 2.95 kHz (left) and 3.0 kHz (right). 1396-37

Figure 4-10 shows the voltage waveforms observed across the same speaker when the other was driven, again with signals of 2.95 kHz (left side) and 3.0 kHz (right side), but with the on-off switch circuit of the Tone-Burst Generator held closed so that continuous waves resulted. Note that the reflection phenomena caused large differences (3:1) in the response of the system at the two frequencies. The larger signal occurs when the phases are such that the reflection subtracts from the direct signal. It would be difficult to determine the transducer's response from the continuous-wave data.

4.3.3 Self-Reciprocity Transducer Calibration.

A transducer can be calibrated by measurement of its

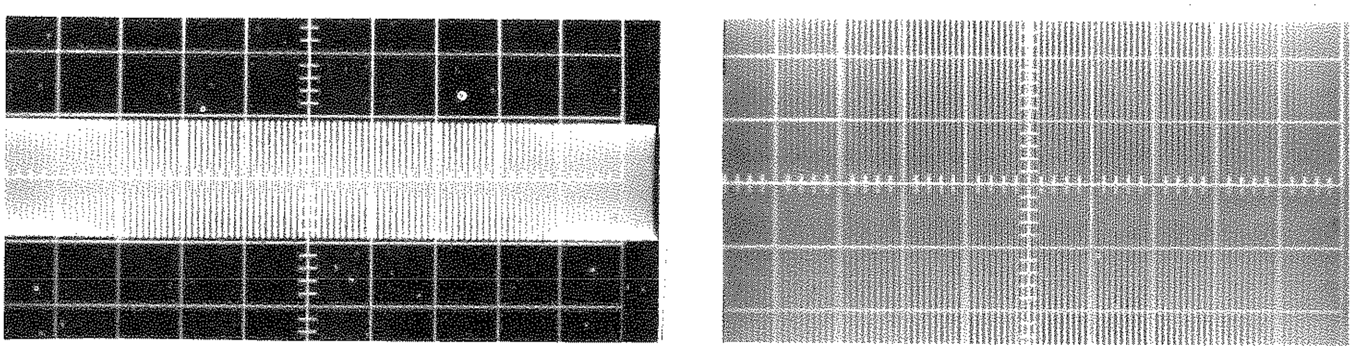


Figure 4-10. Waveforms produced in the same manner as those in Figure 4-9, except the driving signal is a continuous signal of 2.95 kHz (left) and 3.0 kHz (right). 1396-36

response to its own echo.[1] In this self-reciprocity calibration method, the transducer is driven as a speaker or transmitter by a brief tone-burst. The transducer is located near a surface that produces total reflection of the sound waves. The echo is picked up by the transducer acting as a microphone or receiver. Both the desired calibration quantities, the speaker or response and the microphone response, are proportional to the square root of the ratio of the open-circuit voltage produced by the echo to the driving current. The proportionality constant involves the distance between transducer and reflector, the wavelength of the sound signal, and some "handbook properties" of the medium (air, water, etc). A simple calibration scheme suggested by Carstensen can be used to measure the open-circuit voltage even though the transducer is loaded by the driving amplifier and detector.[1]

The ratio of open-circuit voltage to driving current can be considered as an impedance, the "reflectional impedance."[2] Sabin has suggested a simple, self-reciprocity calibration system in which the reflectional impedance is determined from two measurements of transducer impedance made on a conventional bridge.

It is thus possible to make absolute calibrations of a transducer with tone-burst excitation and standard electrical measurements, without an additional calibrated transducer (standard reciprocity tests). The self-reciprocity calibration may be done in a smaller chamber than the standard two-transducer calibration for the same chamber aberrations.

4.3.4 Measurement of Room Acoustics.

The reflection echoes produced in a concert hall are of great interest in evaluating the acoustical quality of the space. A typical test system consists of a sound source on the stage (a pistol shot or a speaker system driven by an electronic sound source), a microphone placed in the seating area, and analyzing equipment driven by the microphone. (See Figure 4-11.) Comparisons of pistol-shot and continuous-wave excitation of a hall have shown significant differences in determining reverberation time, a cardinal acoustic property.[3] These differences indicate that the duration of the exciting signal is important, and a tone burst of controlled properties is very desirable.

An excellent discussion of the response of four halls (La Grande Salle, Montreal; Clowes Hall, Indianapolis; Symphony Hall, Boston; and Philharmonic Hall, New York City) to tone-burst tests is given by Schultz and Watters.[4]

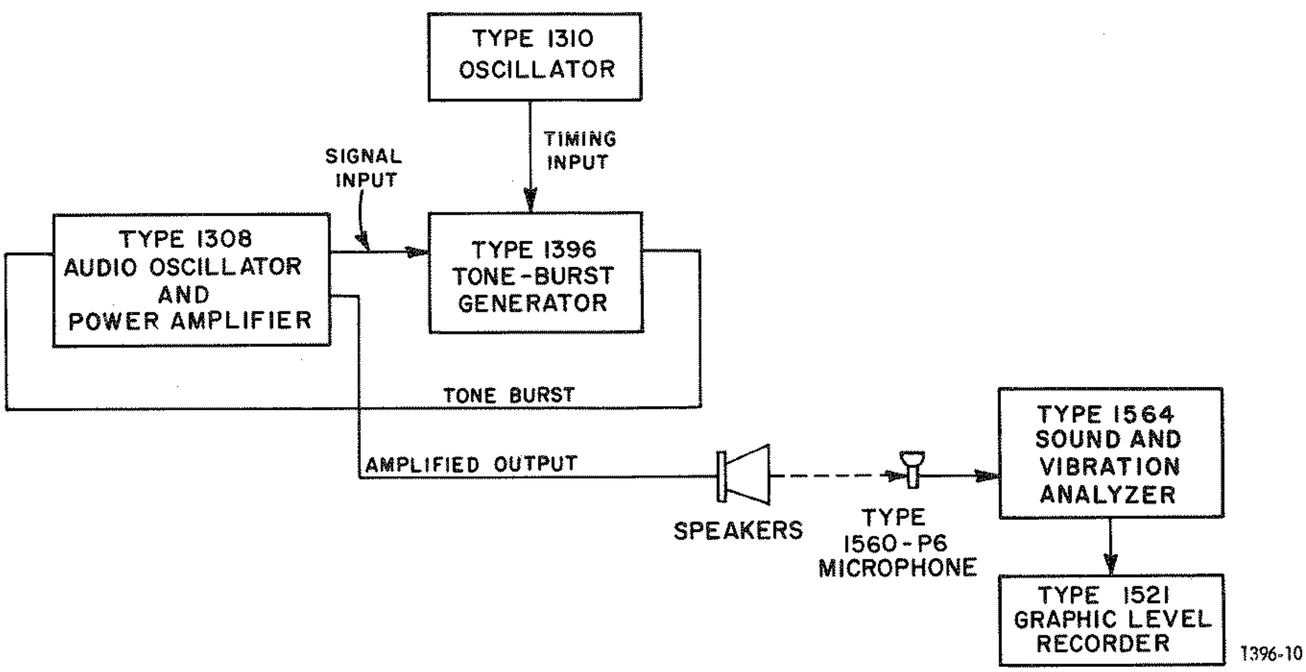


Figure 4-11. Typical test setup for evaluating the acoustical properties of a room.

[1]Edwin L. Carstensen, "Self-Reciprocity Calibration of Electroacoustic Transducers," *Journal of the Acoustical Society of America*, Vol 19, No. 6. November 1947, pp 961-965.

[2]Gerald A. Sabin, "Transducer Calibration by Impedance Measurements," *Journal of the Acoustical Society of America*, Vol 28, No. 4, July 1956, pp 705-710.

[3]Theodore J. Schultz, "Problems in the Measurement of Reverberation Time," *Journal of the Audio Engineering Society*, October, 1963.

[4]Theodore J. Schultz and B. G. Watters, "Propagation of Sound Across Audience Seating," *Journal of the Acoustical Society of America*, Vol 36, No. 5, May, 1964.

4.4 TESTING OF RECTIFYING–TYPE CIRCUITS.

4.4.1 Rectifier Circuits.

Many rectifying circuits lend themselves directly to tone-burst testing, (for example, the adjustment of automatic-gain-control circuits for proper response). The rectification efficiency and time constants of a circuit can be measured easily, for example, with the circuit shown in Figure 4-12. Its associated waveforms are shown in Figures 4-13 and 4-14.

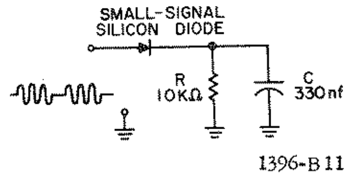
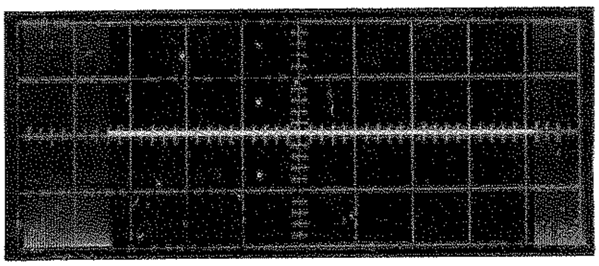
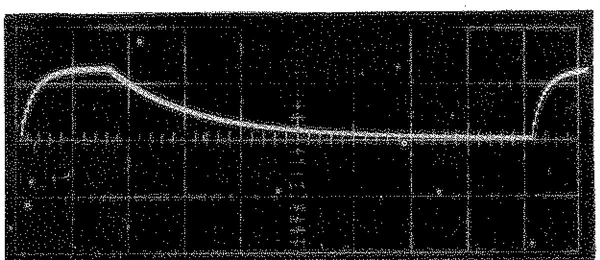


Figure 4-12. Example of a simple rectifying circuit to be tested with a tone burst.



SCALE: 2V/DIV, VERT ; 2 MS/DIV, HORIZ 1396B-12

Figure 4-13. Open-circuit voltage waveform of the Tone-Burst Generator output (32 cycles of 10-kHz signal per burst).



SCALE: 2V/DIV, VERT ; 2 MS/DIV, HORIZ 1396B-13

Figure 4-14. Waveform of capacitor voltage when the voltage waveform of Figure 4-13 is applied to the circuit of Figure 4-12.

4.4.2 Ac Meter Ballistics.

Tone-burst response tests for characteristics such as rise time, fall time, and overshoot, are frequently required for rectifying meters, particularly VU meters. Figure 4-15 shows a test system for measuring the meter deflection as a function of time.[5] The frequency at which the test is performed must be low enough so that the meter can reach full scale in 128 cycles. The tone bursts consist of 128 cycles of test frequency and their spacing is adjusted so that the meter returns to rest at zero between each burst. The Type 1217 or 1340 Pulse Generator acts as a delay circuit. The pulse generator's negative output pulse starts as the Tone-Burst Generator's on-off switch circuit closes, and the pulse ends at a time determined by the settings of the PULSE DURATION controls. The end of this pulse initiates a microsecond flash of the Strobotac® Electronic Stroboscope. The PULSE DURATION controls set the time between the energizing of the meter and the flashing of the bright-light source. The ambient light should be controlled to permit accurate observation of deflection when the flash occurs, and to allow the scale to be seen between flashes.

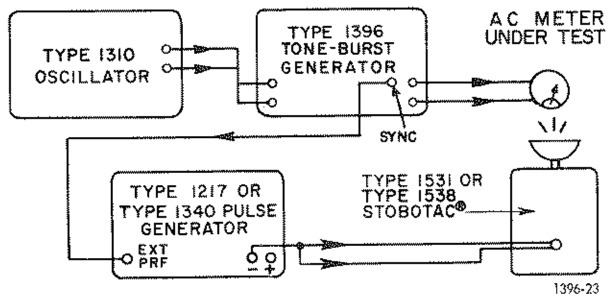


Figure 4-15. Test system for measurement of ac meter deflection as a function of time.

Figure 4-16 is a plot of the deflection vs time of an ac meter when energized by a burst of 128 cycles of 40-Hz signal. The rise time from 10% to 90% of full scale is 0.5 s and the overshoot is 6%, which corresponds to a meter cutoff frequency of approximately 0.9 Hz.

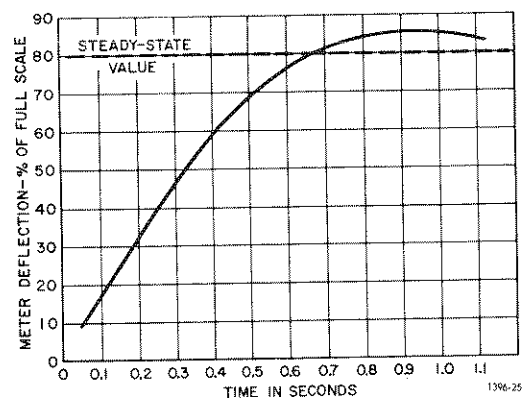


Figure 4-16. Plot of ac meter deflection as a function of time, when the meter is excited by a tone burst.

4.5 TESTING WITH AMPLITUDE TRANSIENTS.

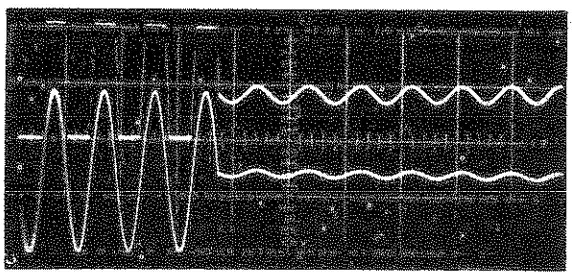
4.5.1 Recovery-From-Overload Tests.

Recovery-from-overload tests are significant for many devices, including amplifiers. In audio amplifiers there may be an occasional overload on a peak input-signal excursion, but these overloads may be quite short and not noticeable if the recovery from overload is fast. In Figure 4-17, the

[5]This system is patterned after a similar system for dc meters, a description of which appeared in the January-February 1962 issue of the *General Radio Experimenter.*

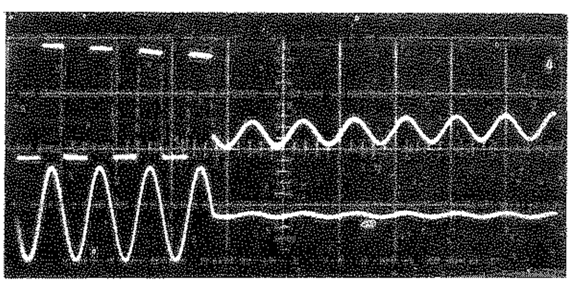
lower trace is the input voltage to an amplifier, and the upper trace is the output voltage. The input voltage has four times the amplitude of the distortion level. Note that overload occurred, but the amplifier returned to normal output as soon as the signal returned to its normal level. Figure 4-18 shows the waveforms of the same amplifier with larger input-voltage swings. The overdrive is now so extreme that the bias point begins to shift at the output. On a different time scale, Figure 4-19, it is apparent that the recovery from overload takes a long time compared to the time during which overload was present. Such distortion might be objectionable whereas pure overload might not.

Overload test signals from the 1396 can be generated by the same method that a tone burst is generated. A variable resistor can be connected between the signal input and output. The resistor allows some signal into the output when the on-off switch circuit is opened (e.g., the signal between bursts in Figures 4-17, 18 and 19) so that signal distortion, in addition to base-line distortion, may be judged after overload.



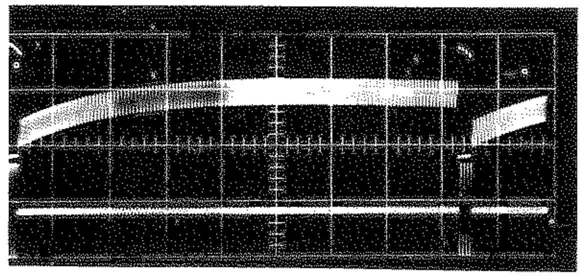
1396B-14

Figure 4-17. Input voltage (four cycles of 1-kHz signal) to an amplifier under test, lower trace; output voltage of the amplifier, upper trace.



1396B-15

Figure 4-18. Amplifier input voltage (lower trace) and output voltage (upper trace) for an input signal (four cycles of 1 kHz) with a voltage that is six times the distortion level.



1396B-16

Figure 4-19. The amplifier with the same input-voltage swings as in Figure 4-18 on a time scale increased ten times.

4.5.2 Music-Power Tests.

Tone-burst signals are required for peak-power tests of amplifiers. These signals prevent loading the amplifier power supplies and thereby shifting the bias points, and prevent excessive power dissipation. Music-power (peak) output tests of power amplifiers for consumer use require that a brief tone burst be applied and its amplitude be increased until 5% distortion is observed.[6] If the distortion level is sharply defined, observation of the amplifier output waveform will indicate distortion. When an accurate distortion measurement is desired, a dual-channel or differential-input oscilloscope can be used and the amplifier input subtracted from the output to give only the distortion products.

Studies indicate that the 14- to 17-dB peak-to-average ratio of music and the efficiency of some audio systems can cause the audio system quality to depend to a large extent on its overload characteristics.[7]

The following example illustrates the use of tone-burst testing in making peak or music-power tests, assessing the nature of overload distortion.

A common three-transistor preamplifier is excited by a burst of 16 cycles of a 1-kHz signal. Figure 4-20 shows the output signal (upper illustration) and input signal (lower) when the input signal level is adjusted just below the clipping level. When the input level is increased by 15 dB, the output waveform is as shown in Figure 4-21.

The half-wave type rectification shown is a result of using an output stage (emitter-follower) whose ability to deliver current to the load depends on the current polarity. The slower deformity shown in the output waveform is due to the charge and discharge of a coupling capacitor.

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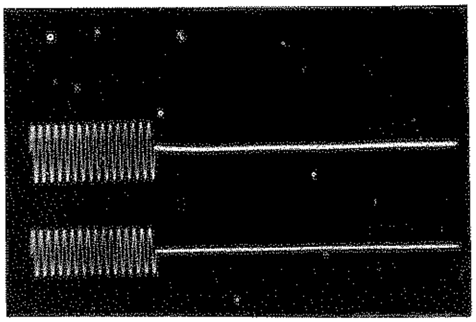
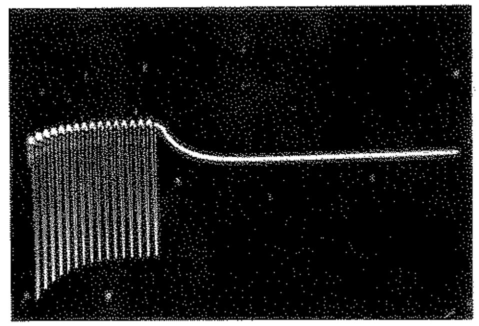
[6] *EIA Standard RS-234-A*, November 1963, "Power Output Ratings of Packaged Audio Equipment for Home Use," Electronics Industries Association, 11 West 42nd Street, New York 36, New York ($0.25).

[7] R. A. Greiner, "Power Amplifier Overload Characteristics and Their Importance," *Audio*, June 1966, pp 19 ff.



1396B-17

Figure 4-20. Small signal output (upper) and input (lower) waveforms with a 16-cycle burst of 1-kHz input adjusted just below the clipping level.



1396B-18

Figure 4-21. Output of a 16-cycle, 1 kHz burst after increasing input amplitude 15 dB above the clipping level.

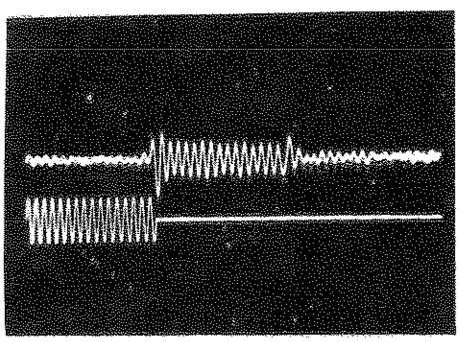
4.5.3 Loudspeaker Distortion Measurements.

Distortion measurements can be made with tone-burst excitation of speakers.[8,9] A gated microphone responds to the signal produced by the speaker after the tone burst has been cut off. This "hangover" is a measure of the distortion of the speaker. Such systems are suitable for sweep-measurement techniques and can be at least partially automated. The following example demonstrates the ease with which loudspeaker performance can be evaluated by tone-burst tests. In this example a high-quality power amplifier drives an 8-in. speaker. Figure 4-22 shows the waveforms of sound pressure resulting from the tone-burst excitation. The sound-pressure waveforms are observed with a sound-level meter and an oscilloscope.

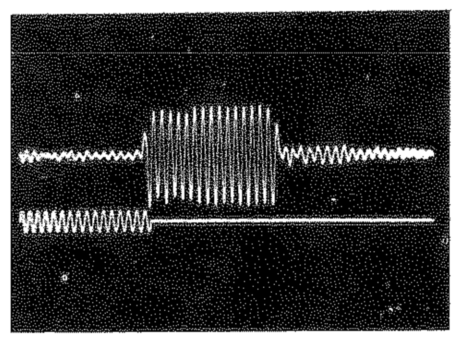
The speakers are not mounted in any enclosures. However, the tests are made in a small anechoic room.

[8] M. C. Kidd, "Tone-Burst Generator Checks A-F Transients," *Electronics*, Vol 25, No. 7, July 1952.

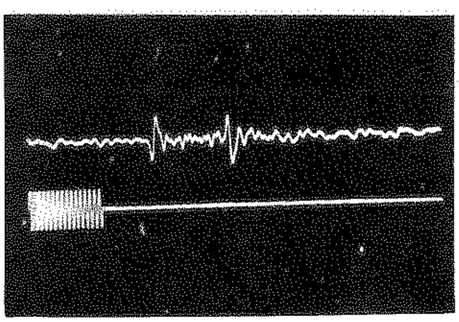
[9] M. J. Whittemore, "Transistorized Tone Burst System for Transient Response Testing of Loudspeakers," *Journal of the Audio Engineering Society*, Vol 10, No. 3, July 1962.



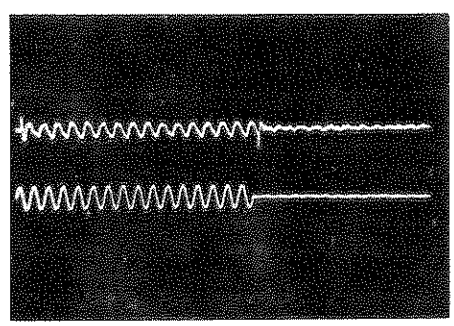
A. A midrange speaker excited by 16 cycles of 5 kHz.



B. Same as A, except a widerange speaker is used.



C. Same as A, with 16 cycles of 8-kHz excitation.



1396B-19

D. Same as A, with 16 cycles of 270-Hz excitation.

Figure 4-22. Waveforms of sound pressure (upper) resulting from tone-burst excitation (lower) of 8-in. speakers.

Major room responses at high frequencies can be eliminated from the test response when tone bursts are used since the responses are time separable – radar-like separation of direct and reflected signals. A continuous tone test can be greatly affected by reflections.

In Figure 4-22 the waveforms for a midrange speaker (A, C and D) show spikes at the start and end of the tone burst when the speaker is operated at the extremes of its range. These attack transients are not detectable from a continuous tone test and are obscured in a pulse test.

4.5.4 High Power Transients.

The General Radio Type 1308 Audio Oscillator and Power Amplifier can be combined with the 1396 Tone-Burst Generator to produce tone bursts with power content as high as 200 W. The 1308 combines a 20-Hz to 20-kHz oscillator and a power amplifier capable of delivering 200 W within the band of 50 Hz to 1 kHz. The 1396 can be connected between the oscillator and the amplifier of the 1308. Remove the shorting strap between terminals J201 and J202 on the oscillator. Connect the ≈1-volt signal from the OSC OUTPUT terminals (J201) at the rear of the 1308 to the SIGNAL INPUT terminals of the 1396 through a coupling capacitor, and connect the SIGNAL OUTPUT terminals of the 1396 to the AMP INPUT terminals (J202) of the 1308. This system produces tone bursts similar to those issuing from the 1396 alone, but of much higher power level.

4.5.5 Generation of Line Transients.

A system that produces controlled transients in the power-line signal is shown in Figure 4-23. The step-down transformer isolates the instruments from line voltage and drops the voltage to the proper range for operation of the instruments (0.5 V rms). The boost transformer adds the switched and amplifier tone burst to the power-line supply

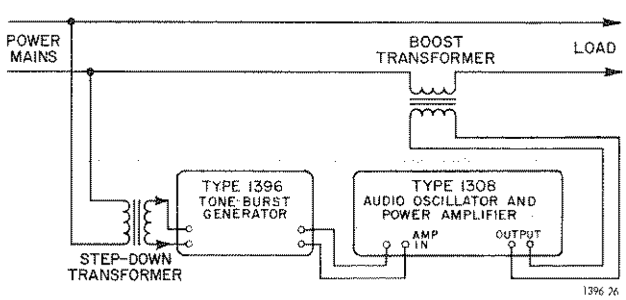


Figure 4-23. Tone-burst system for generating power-line transients.

to produce a controlled transient. The polarity of the output connection must be such that the amplifier voltage is added to the line voltage. With this system, up to 200 W of power may be put into the incremental part of the transient. The boost transformer may be omitted if the total load current is less than 5 A rms.

4.5.6 Filter Testing.

The response of a passband filter to a suddenly applied signal in its passband is a commonly required measurement. Attempts to deduce the desired response from the results of a step-function test are tedious, particularly if the passband is narrow. Use of a continuous-signal test is equally difficult, particularly if a minimum-phase network is not involved, in which case, phase, as well as amplitude, information is required. Testing with a Tone-Burst Generator produces the desired passband transient response directly.

4.6 OPERATING AT HIGH POWER LEVELS.

Tone-burst testing allows the average signal power to be kept arbitrarily low and, at the same time, the pulse, or burst, power level may be high. Such operation may be required if the device under test has nonlinearities (i.e., the test properties depend on power level) and the test equipment cannot operate continuously at the desired signal or power levels.

4.7 TESTING OF LOW–SPEED DIGITAL EQUIPMENT.

The Type 1396 Tone-Burst Generator can operate on any periodic waveform. If square or rectangular waveforms are applied to the instrument, it can generate pulse words at a bit rate determined by the OUTPUT ON and OUTPUT OFF indicator-switch settings or by an external timing source, or both. Such words are useful in testing digital equipment. For testing binary devices the +1 setting of the CYCLE COUNT switch is useful, since it permits testing with words containing an odd number of bits.

4.8 OPERATION WITH NONPERIODIC SIGNALS.

The Tone-Burst Generator will operate on signals that are not periodic, such as noise. The timing and counting circuits will produce a count when the input signal or external timing signal passes through the triggering level with the proper slope. Between each count the signal must eventually reverse slope long enough to produce a voltage change that will reset the timing circuits, allowing another count to be made.

Theory–Section 5

5.1 INTRODUCTION.

The Type 1396-B Tone-Burst Generator alternately interrupts and passes as an input signal, thus chopping into bursts a periodic input signal or a continuous tone applied to the input. The output "on" and "off" intervals of the tone burst may be determined by either cycle counting of the input signal or an externally applied timing signal by actually timing the intervals, or both; that is, the "on" interval may be timed and the "off" interval counted, or vice versa, if desired.

In cycle counting, counting circuits set the on and/or off intervals in binary multiples of one period (1, 2, 4, 8, 16, 32, 64, and 128) of the input signal or the external timing signal. The duration of the bursts and the time between bursts are then equal to a number of cycles (periods) in binary multiples determined by the settings of front-panel switches and controls.

The timed intervals are determined by timing circuits that control the output switching. The timing circuits are controlled by front-panel switches and controls that allow output on and off intervals from 10μs to 10 s to be selected.

The exact phase at which the tone burst starts and stops is determined by the phase point of the input-timing or external-timing signal selected to activate the counting and timing circuits. Front-panel switches enable any phase of the timing signals to be selected, thus allowing the bursts to start and stop at any phase. This also makes the bursts phase-coherent from burst-to-burst.

In the timed mode, however, the phase-coherency feature may cause the burst to vary from the selected time duration since switching actually occurs at the selected phase point of the timing signal.

The count mode may be advanced by one period by the CYCLE COUNT switch on the front panel which sets the counting circuits to the state they could be in if they had received one cycle of a timing signal. This provides output on and off durations of 2, 3, 5, 9, 17, 33, 65, and 129 cycles. Front-panel controls can also turn on the output continuously or can provide single bursts.

5.2 GENERAL DESCRIPTION.

Figure 5-1 shows a simplified block diagram of the 1396. For this general discussion the 1396 is considered to be comprised of four major circuit groups: (1) counting and timing circuits, (2) input amplifier, (3) on-off switch circuit, and (4) output amplifier. The heavy line in Figure 5-1 denotes the tone-burst signal path. The input signal, which is switched on and off to provide the tone bursts, is applied to the input amplifier where it is amplified and applied to the on-off switch circuit. The signal is also fed to the counting and timing circuits if an external timing signal is not used, initiating signals that control the state of the on-off switch circuit. The on-off switch circuit, under control of the counting and timing circuits, opens or closes for periods determined by control settings on the front panel. When closed, the on-off switch circuit passes the signal to the output amplifier, where it is amplified and applied to the SIGNAL OUTPUT terminals on the front and rear panels.

The counting and timing circuits therefore control the intervals that the signal is on and off. As mentioned previously, these circuits operate in three modes–timed, cycle count, and mixed (timed and cycle-count). Either or both the on and off intervals may be set to a specific time duration adjustable from 10μs to 10 s in the timed mode. In the cycle-count mode the interval is measured in a whole number of periods of a timing signal, usually the input signal. That is, either the on or off durations, or both, are made to be equal to a certain number of cycles of the timing signal. The count may be set at any number in the binary sequence of one through 128. The CYCLE COUNT front-panel switch + 1 position allows the option of adding one count to the selected count so that the on and off intervals are an odd rather than even number of periods. If it is desired, an external timing signal may be applied to the timing circuits. This signal is operated in the same manner as the input signal, except when it is desired to open or close the on-off switch circuit directly with the signal, foregoing the timing or counting provided by the counting and timing circuits.

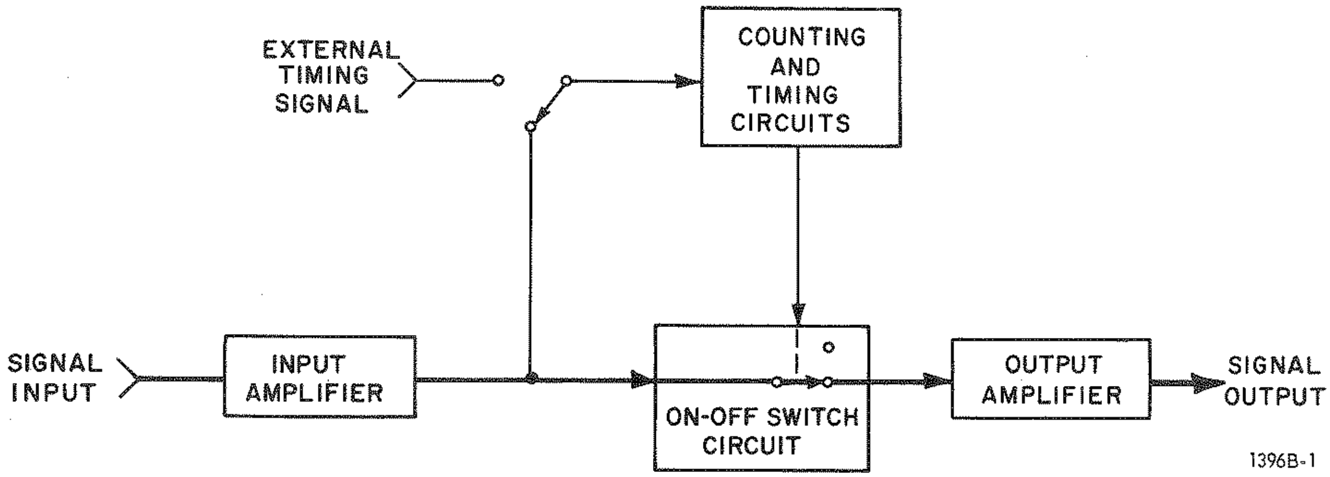


Figure 5-1. Simplified block diagram of the Type 1396 Tone-Burst Generator.

In either the timed or count mode, the on-off switch circuit opens and closes at the same point (phase) of the input waveform on every burst, thus producing phase-coherent bursts. This is desirable when short bursts with reproducible and consistent spectra and waveform are required. Because of the coherence feature, the on and off intervals are always whole numbers of input periods, and adjustment of the interval in the timed mode therefore is not a "smooth" adjustment but is automatically "stepped" in increments of one period.

The cycle-count mode produces bursts of known duty ratio that is independent of frequency or frequency change. The timed mode provides intervals longer than can be obtained by counting 129 cycles and in this case the jumps that may occur in interval produce negligible effect. The timed mode is also useful in cases where a specific number of cycles is required in or between bursts, and the binary sequence (or binary sequence plus one) does not include that number.

5.3 BLOCK DIAGRAM DESCRIPTION.

Figure 5-2 shows a detailed block diagram of the 1396. In addition to the counting and timing circuits, input and output amplifiers, and on-off switch circuit described in the previous paragraph, Figure 5-2 shows the other circuits which comprise the 1396. These include the input-trigger circuit, pulse-shaper circuit, lamp-driver multivibrator, and sync amplifier.

As shown in Figure 5-2, the input signal is applied to the input amplifier via the INPUT SIGNAL front-panel connector. The input amplifier, which controls the input impedance, amplifies the signal and applies it to the on-off switch circuit. The on-off switch circuit, under control of the counting and timing circuits, allows the signal to be applied to the output amplifier thereby supplying the output signal. The output signal path is indicated by the heavy line in Figure 5-2.

Since Figure 5-2 shows the TIMING switch on the rear panel set to INT (NORM), the input signal provides the counting and timing circuits with the timing signal that controls the state of the on-off switch circuit. The input signal, therefore, is also applied to the input-trigger circuit. The input-trigger circuit consists of differential-amplifier pair driving a flip-flop circuit. The circuit provides a timing trigger pulse to the counting and timing circuits via the pulse-shaper circuit. The circuit produces a rectangular output with signal rise and fall times independent of the input signal. The voltage level of the input signal at which a trigger pulse occurs is established by the front-panel TRIGGER LEVEL control. This level can be set anywhere in the -10- to +10-V range. The positive-going or negative-going slope of the trigger pulse can be selected at this point by the front-panel SLOPE control for application to the pulse-shaper circuit. The SLOPE control can select the output of either side of the flip-flop. The SLOPE and TRIGGER LEVEL controls therefore determine the point on the input cycle at which the timing circuitry is pulsed. Since the off and on switching is coincident with the pulsing of the timing circuitry, these controls establish the relative phase of the input signal at which the on-off switch circuit is opened or closed.

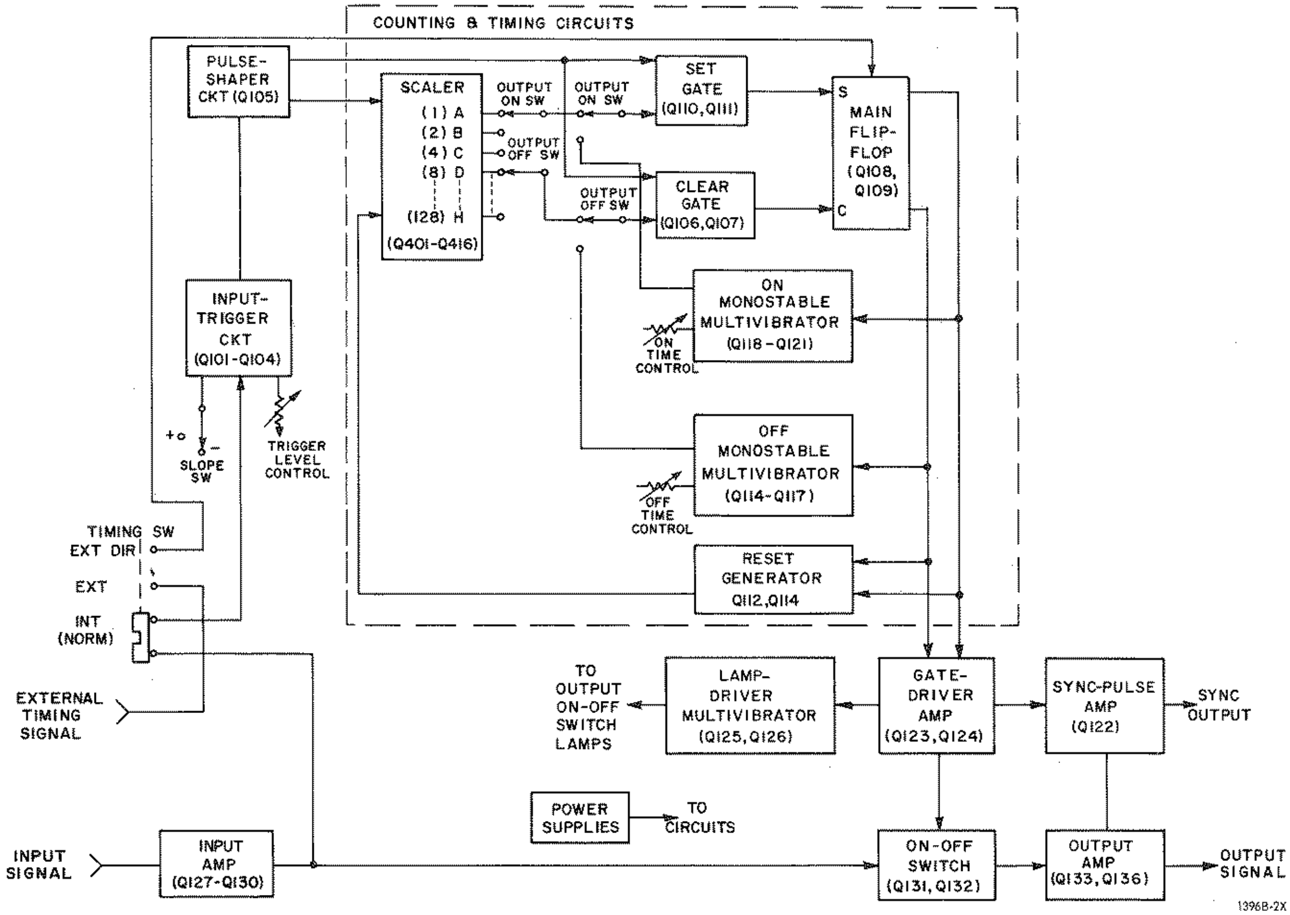


Figure 5-2. Detailed block diagram of the Type 1396 Tone Burst Generator.

The pulse-shaper circuit produces a short-duration negative pulse each time the rectangular input signal makes a positive excursion. The pulse is applied to the binary-scaler circuit and main flip-flop gates. These circuits, together with the on and off monostable multivibrators, main flip-flop, and reset generator, comprise the counting and timing circuits.

The scaler is a binary counter comprised of eight cascaded flip-flops. Each flip-flop has a 2-to-1 ratio of input to output pulses. Therefore, the eight flip-flops, respectively, denote counts of 1, 2, 4, 6, 8, 32, 64, and 128. The outputs of the flip-flop are labeled A to H in Figure 5-2.

The scaler counts the number of trigger pulses. The OUTPUT ON and OUTPUT OFF indicator-switch allow selection of the output of any one of the eight flip-flops for application to the main flip-flop gates.

The main flip-flop set and clear gates are logic NAND circuits that pass a signal when two signals are simultaneously present at the input to the gates. The set and clear gates, therefore, set and clear the main flip-flop, respectively, when the proper inputs are present. In its set state the main flip-flop produces a signal that opens the on-off switch circuit. Conversely, in the clear state the flip-flop produces a signal that closes the on-off switch circuit, allowing the signal to pass.

The OUTPUT ON and OUTPUT OFF indicator-switches select the number of cycles the switch will be open or closed. For an "on" interval in the cycle count mode, the OUTPUT ON switch selects the number of input or timing signal cycles (1, 2, 4, 8, 16, 32, 64, or 128) it is desired to close the switch, providing an output signal. Assuming all the scaler flip-flops are reset, the scaler counts the number of trigger pulses in binary form. Each trigger pulse in the case being described corresponds to one cycle of the input signal.

At the count of one less than the desired count selected by the OUTPUT ON indicator-switch, (a trigger pulse is applied to the scaler at zero cycles) the appropriate scaler flip-flop (A to H) is set, applying its output to the clear gate. The next trigger pulse, which denotes the cycle count desired, is applied directly to the gate. The presence of two appropriate signals at the gate activates the gate, applying a pulse to the clear side of the main flip-flop. The main flip-flop applies the signal produced at the clear side output of the flip-flop to the gate-driver amplifier, which in turn applies a signal to the on-off switch circuit. This signal closes the switch, allowing the input signal to pass through.

When the main flip-flop changes its state, the output is sensed by the reset-pulse generator. The generator produces a reset pulse that is applied to the appropriate scaler flip-flop, resetting the flip-flop.

The cycle count output "off" interval is produced in the same manner as the "on" interval. The OUTPUT OFF indicator-switch selects the cycle count in binary multiples the same as the OUTPUT ON indicator-switch. After the reset pulse resets the scaler flip-flops, the scaler counts the number of pulses to one cycle less than the selected count. At one cycle less than the selected count, the appropriate flip-flop selected by the OUTPUT OFF indicator-switch is set, applying its output to the main flip-flop set gate. The next trigger pulse, which is applied directly to the gate, activates the gate, thereby setting the flip-flop at the exact count selected.

The flip-flop output is applied to the gate-driver amplifier, which produces a signal that opens the on-off switch circuit, inhibiting an output. The reset generator produces another reset pulse and applies it to the appropriate scaler flip-flop, resetting the flip-flop. The on-off cycle is then repeated.

The CYCLE COUNT switch on the front panel can be used to set the on and off periods to 2, 3, 5, 9, 17, 33, 65, or 129 cycles of duration. When set to the +1 position the switch resets the first flip-flop in the scaler to the state it would normally have after one input pulse. This allows counting in the above sequence.

The off and on monostable multivibrators replace the binary scaler in the timed mode. The off and on multivibrators are associated with the respective states of the on-off switch circuit. The off and on times are determined by the time the multivibrators are triggered into their unstable states. This is determined by the setting of the OUTPUT ON and OUTPUT OFF indicator-switches and the ON TIME and OFF TIME controls on the front panel. The multivibrators are triggered into their unstable state by the setting or clearing of the main flip-flop. An output from the clear side of the flip-flop is provided to the off multivibrator and an output from the set side of the flip-flop is provided to the on multivibrator. Outputs of the multivibrators are in turn applied to the respective set or clear flip-flop gates.

When trigged into its unstable state the particular multivibrator remains in that state for a time determined by above mentioned panel controls and switches. When the multivibrator returns to its stable state it applies a signal to its respective gate allowing the next trigger pulse to activate the gate and change the state of the flip-flop. This in turn either opens or closes the on-off switch circuit, depending on which multivibrator is in its stable state. The other multivibrator is then set in its unstable state by the change in the state of the scaler flip-flop, provided the particular OUTPUT OFF or OUTPUT ON indicator-switch is set to a time setting, and remains in the unstable state, inhibiting its respective flip-flop gate circuit for a time determined by the time controls. At the end of the selected time, the multivibrator returns to its stable state, applying a signal to the gate. This allows the next trigger pulse to activate the gate and change the state of the main flip-flop, thereby either opening or closing the on-off switch circuit. The sequence is then repeated.

Combinations of cycle counted and timed intervals for opened and closed on-off switch circuit states are possible. Specific examples of the cycle counted and timed modes and combinations thereof (mixed mode) are described in paragraph 5.4.

The reset generator is a series gate-type circuit that produces a negative-going reset pulse each time the main flip-flop changes to the set and clear states. The reset pulse is applied to all the flip-flops in the scaler circuit, resetting the one that is in the set state so the scaler can begin a new pulse count.

The gate-driver amplifier circuit consists of a differential amplifier pair. The circuit produces positive and negative pulses that drive the on-off switch circuit. The gate-driver circuit produces a negative pulse when the main flip-flop is cleared, closing the on-off switch circuit and allowing the input signal to pass. The circuit opens the on-off switch circuit when the main flip-flop is set, blocking the input pulse.

The gate-driver amplifier also drives the sync pulse amplifier and lamp driver multivibrator circuits. The sync amplifier provides a convenient synchronization signal which is applied to SYNC OUT connector on the rear panel. The lamp multivibrator drives the OUTPUT ON and OUTPUT OFF indicator-switch lamps, indicating the operational state of the instrument.

Two power supplies are provided, the main-circuit-board power supply and scaler power supply. The main-circuit-board supply provides -20 and +20 V to all the circuits except the scaler circuit. The scaler power supply provides +7 V and -1.5 V to the scaler circuit. Both supplies are unregulated and are fed by a power transformer in the instrument.

An external timing source may be used in place of the input signal to pulse the counting and timing circuits. As shown in Figure 5-2, the TIMING switch may be set to EXT or EXT DIR and an external signal of 10 V amplitude applied to the EXT TIMING connector at the rear panel. When the TIMING switch is set to the EXT position, the external timing signal replaces the input signal as a timing input and operation of the instrument is the same as that described previously. When set to EXT DIR the switch interrupts the external timing signal, applying it directly to the main flip-flop. The signal can set or clear the flip-flop, thus opening or closing the on-off switch circuit.

5.4 SEQUENCE OF OPERATION.

The Type 1396 can operate in the cycle-count mode, timed mode, or mixed mode (timed and cycle-count modes). The following paragraphs describe the various modes of operation. In the following discussion, when referring to the main flip-flop circuit, a logical "1" is considered to be approximately zero volts, a logical "0" approximately -5 V. When referring to the scaler circuits and monostable multivibrator circuits, a logical "1" is considered to be a positive voltage and a logical "0" approximately 0 V.

5.4.1 Cycle-Count Mode.

Figure 5-3 illustrates the sequence of operations in the COUNT mode. See Figure 5-2, if necessary, for the circuit functions involved. In this example the scaler holds the on-off switch circuit open for eight cycles of input signal and holds the on-off switch circuit closed for four cycles of input signal. The scaler is a cascade of eight flip-flops with provision for taking an output from any one of the eight. The selected scaler output is applied to the main flip-flop and subsequently to the on-off switch circuit. An accumulative time delay, or propagation delay, occurs as a signal propagates through the flip-flop chain; thus, the actual point in the input cycle time at which the on-off switch circuit would open or close is delayed by an amount dependent upon which scaler output is selected. To avoid this propagation-delay effect, the output just before the period desired is selected from the scaler chain and applied to the set or the clear gate. The next input pulse enables the particular gate, applying a pulse to the main flip-flop to set or clear the flip-flop.

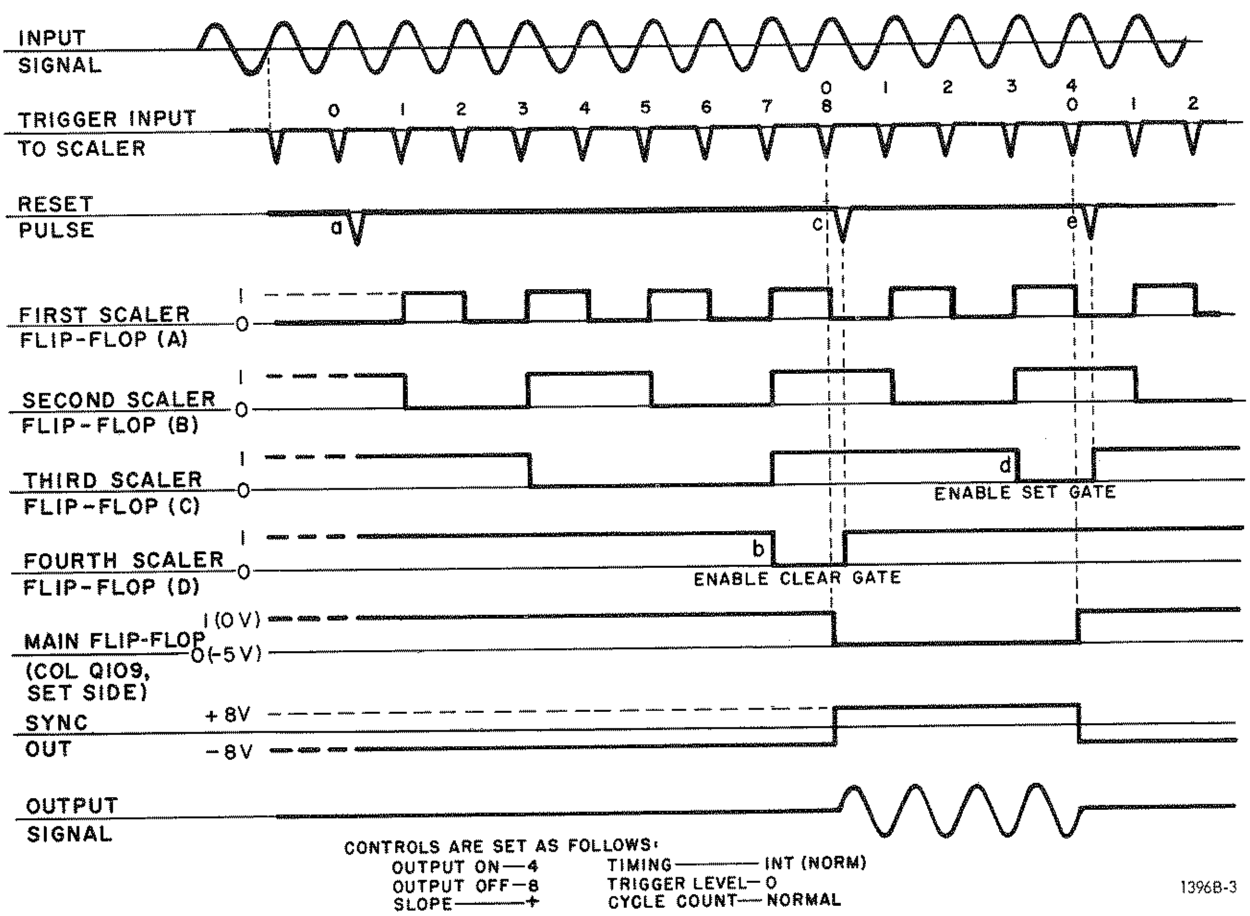


Figure 5-3. Cycle-Count Mode Timing Diagram

Figure 5-3 shows the timing sequence beginning at a point in the cycle at which the scaler has received a reset pulse (point a, Fig. 5-3) from the reset generator. The input-trigger circuit and pulse-shaper circuit supply one input-trigger pulse to the scaler for each cycle of input signal. After seven pulses have been received, flip-flop D (Figure 5-2) goes to the zero state (point b, Figure 5-3) applying its output to clear the gate. The eighth input, applied to the clear gate, enables the gate, clearing the main flip-flop. The one-zero transition of the main flip-flop activates the reset generator, producing a reset pulse (point c), and also causes the on-off switch circuit to turn on the output signal. The reset pulse is applied to the scaler, resetting flip-flop D. After the scaler has received three more input pulses, flip-flop C goes to the zero state, applying its output to the set gate (point d). The next input pulse, the fourth, enables the set gate, causing the main flip-flop to go from the "0" to the "1" state. This transition of the main flip-flop causes the reset generator to produce another reset pulse, which resets flip-flop C (point e) and also causes the on-off switch circuit to turn off the output signal. The cycle then repeats.

The OUTPUT ON indicator-switch and OUTPUT OFF indicator-switch determine the points in the flip-flop chain at which the outputs to the set and clear gates are taken and, thus, the duration that the switch holds the output signals on and off, respectively. Since the scaler is a straight, binary divider chain, the ON-OFF indicator-switches furnishes a choice of 1, 2, 4, 8, 16, 32, 64, or 128 periods of timing signal per interval. The CYCLE COUNT switch on the front panel allows the option of adding one cycle to the number of cycles counted in the sequence above, providing odd numbers of periods in the on or off intervals as well as better coverage of small number counts. The CYCLE COUNT switch, when set to the +1 position, resets flip-flop A to its "1" state instead of its "0" state. This resets the scaler to the condition it would normally have after one input pulse. In some cases it may be desired to time the on-off switch circuit from a signal other than the input

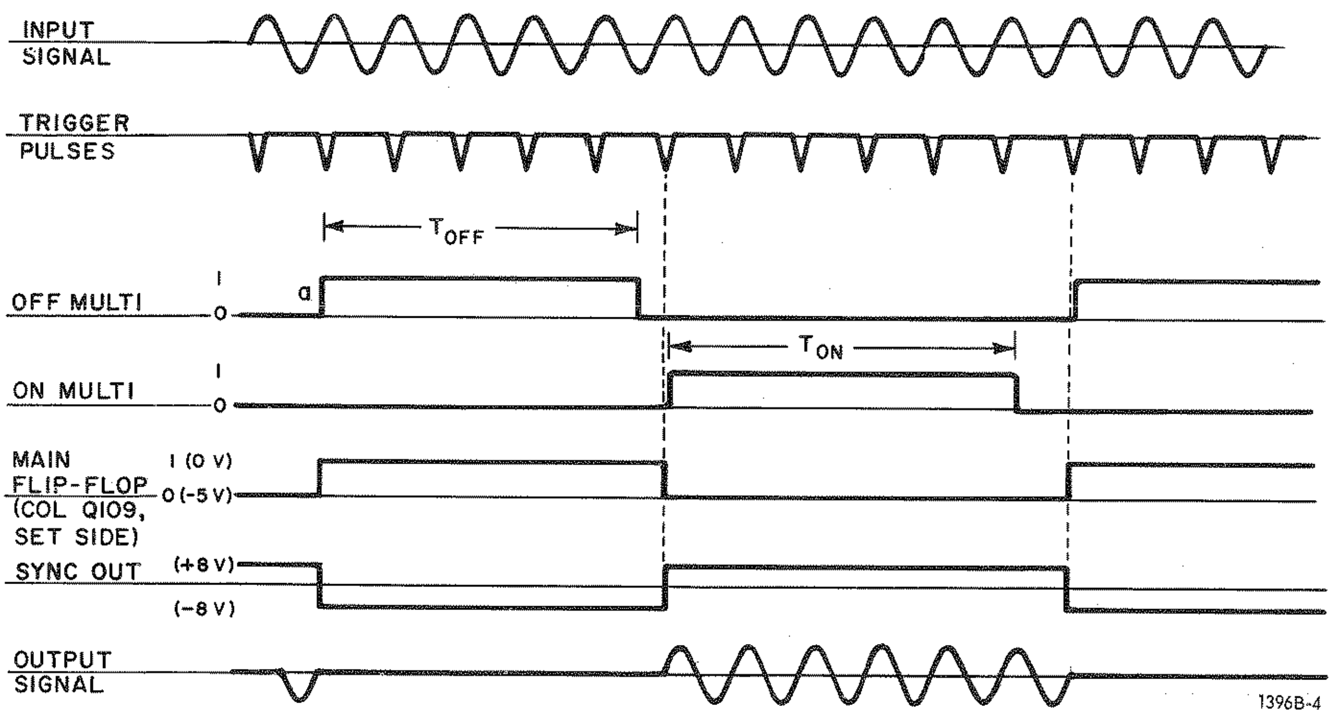


Figure 5-4. Timed-Mode Timing Diagram.

signal. In such a case, the TIME switch on the rear panel can be set to the external (EXT) position, connecting main flip-flop circuit directly to the external timing (EXT TIMING) input jack, also on the rear panel of the instrument.

5.4.2 Timed-Mode Operation.

Figure 5-4 is a timing diagram for the 1396 when operated in the timed mode. Operation in the timed mode is the same as operation in the cycle-count mode, with the exception that two monostable multivibrators replace the scaler in its reset circuit. The timing diagram begins with the zero-one transition of the main flip-flop (point a, Figure 5-4). This transition triggers the off monostable multivibrator (off MM) into its unstable state, producing a positive voltage that inhibits the clear gate. The off MM remains in this state for a period of time, T_{OFF}, determined by the OFF TIME control and the setting of the OUTPUT OFF indicator-switch, and then it returns to its stable or "0" state, applying an enabling signal to the clear gate. The next input trigger occurring after the end of T_{OFF} enables the clear gate, clearing the main flip-flop which goes to its "0" state. This closes the on-off switch circuit. The one-zero transition of the main flip-flop triggers on the monostable multivibrator (on MM) into its unstable state for a period of time T_{ON}, determined by the ON TIME control and the setting of the OUTPUT ON indicator-switch. At the end of interval T_{ON} an enabling signal is applied to the set gate, allowing the next input pulse to set the main flip-flop. This causes the set side to go to the "0" state, turning off the output signal.

The on-off switch circuit, it should be noted, opens and closes in exact synchronism with the trigger pulses regardless of the setting of the on-or off-time intervals. This guarantees that the tone burst is phase coherent; i.e., the tone burst starts and ends at the same point of the input signal waveform on every tone burst. If the ON TIME control or the OFF TIME control is adjusted smoothly, it should be noted that the intervals change in jumps of one cycle of input signal as a result of the switching action. Such jumps can also be created by changes in the input or timing frequency, by drift or noise in the on and off MM's, and in general represent such a small jump in the total interval that it can be neglected.

5.4.3 Mixed Mode.

The 1396 can be operated in the mixed mode, i.e., the "on" time may be timed and the "off" time may be determined by cycle count, or vice versa.

Included as part of the mixed-mode operation is the ability to provide a continuous tone as well as single tone bursts. A continuous tone is provided by setting the OUTPUT ON indicator-switch to CONT. This keeps the on MM in the unstable state, not allowing the main flip-flop to be set, thereby opening the on-off switch circuit. A single burst is provided by setting the OUTPUT OFF indicator-switch to SINGLE BURST, setting the OUTPUT ON indicator-switch to any position other than CONT, and pressing the SINGLE BURST pushbutton on the front panel. This causes a single burst of duration determined by the OUTPUT ON indicator-switch (and ON TIME control if the burst is timed). Pressing the SINGLE BURST pushbutton switch causes the off MM output and trigger pulse to clear the main flip-flop, closing the on-off switch circuit for the selected time or cycle interval.

5.5 CIRCUIT DESCRIPTION.

Schematic and circuit board layout diagrams are in Section 7. Figure 7-4 shows a schematic of all the instrument's circuits, except the scaler circuit and its associated power supply and the power transformer, which are shown in Figure 7-6, and switches and controls, which are shown in Figure 7-7. Refer to these drawings for the following discussion.

5.5.1 Input Amplifier.

When an input signal is applied to the input amplifier. the attenuator, comprised of resistors R193 and R194, attenuates the input signal to half value, and applies it to the input of the differential pair of transistors, Q127 and Q128. Feedback transistor Q129 applies negative feedback such that the base of transistor Q128 tracks the base of Q127 very closely. Thus the total voltage gain from input terminals to output at collector of Q128 is one-half. Transistor Q130 acts as a 10-mA current source that improves the efficiency of the input amplifier and allows its output to swing symmetrically about ground.

5.5.2 Output Amplifier.

The output-amplifier circuit configuration is the same as the input amplifier, but the circuit operates at a higher current and power levels. The DC ZERO adjustment, R902, inserts a controlled voltage offset between the input and output that "bucks" any offset produced by other circuitry and also the offset produced by the PEDESTAL NULL control. As in the case of the input amplifier, the high, negative open-loop gain causes the input bases of the differential amplifier, comprised of transistors Q133 and Q134, to virtually track one another. Since the output is fed back to the base of Q134 by an attenuator, which reduces its amplitude by approximately 2.5, the total gain between the input base at Q133 and the output terminals is approximately 2.5. The total gain for the signal path between the INPUT SIGNAL terminals and OUTPUT SIGNAL terminals is approximately one. If an accidental short circuit of the signal-output terminals occurs, R222 limits the current in the output stage to a safe level.

5.5.3 Input-Trigger Circuit.

The input-trigger circuit consists of a differential amplifier, comprised of transistors Q101 and Q102 driving a flip-flop comprised of Q103 and Q104. The relatively large signal applied to the base of Q101 overdrives the differential pair, causing the current to shift from one collector to the other. The input voltage at the base of Q101 has little effect on differential output current unless the input voltage is within approximately 50 mV of the voltage at the base of Q102.

As the input voltage swings from its most negative value toward its most positive value, the output current remains in Q101 until the input voltage approximately equals the voltage at the base of Q102, at which point the output current abruptly changes from Q101 to Q102 and remains constant in Q102 as the input voltage continues its positive swing.

The effect for negative-going input voltages is similar and operation is depicted in Figure 4-5. To further improve the steepness of the rise and fall of the output of the input trigger circuit, the differential pair drives the flip-flop, which regeneratively switches from one state to the other, producing an output whose rise and fall times are independent of the input signal.

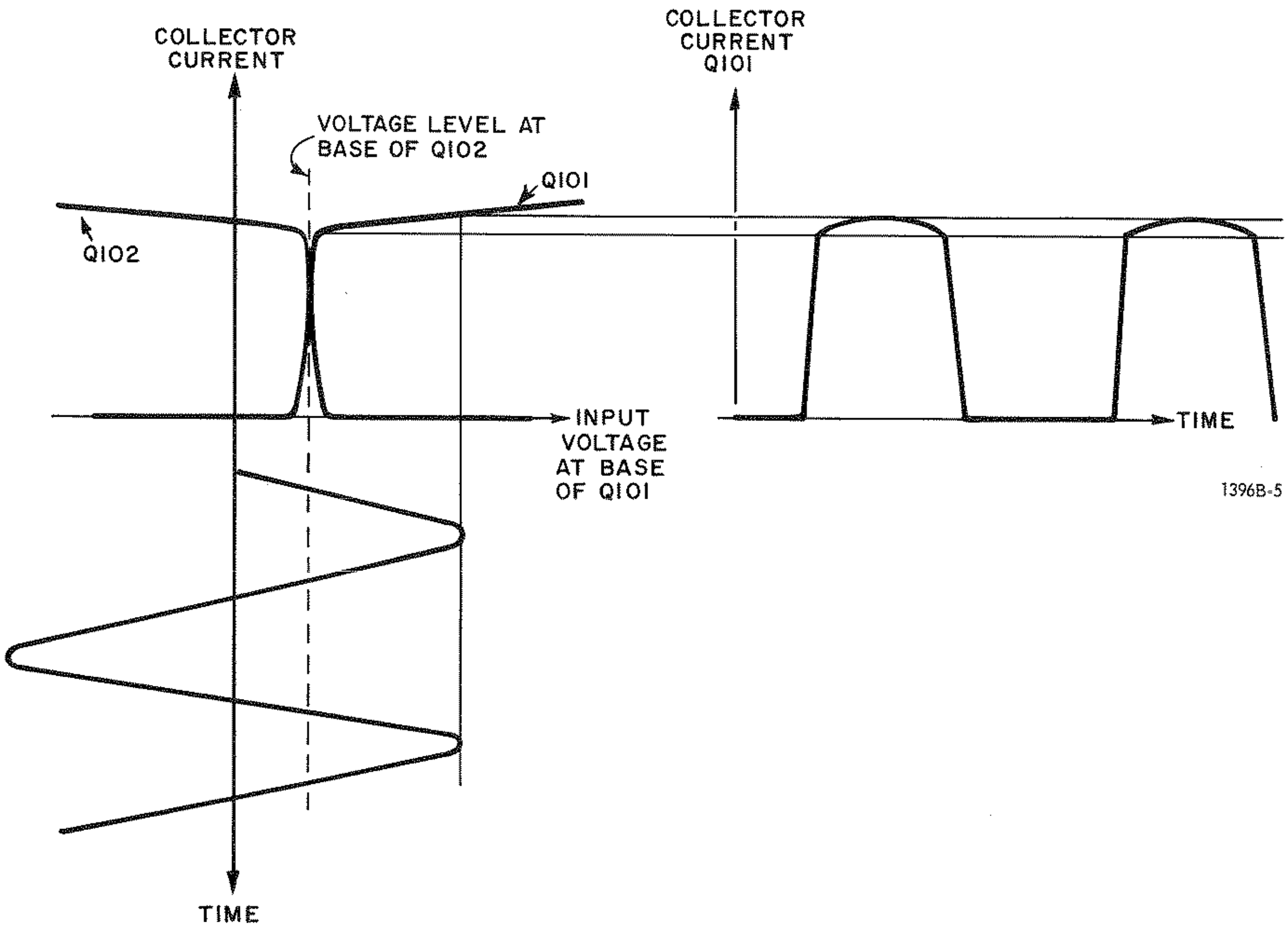


Figure 5-5. Input-Trigger Circuit Operation

R905, the TRIGGER LEVEL front-panel control, adjusts the voltage at the base of Q102 and thereby the level at which switching will occur. The SLOPE switch, S905, allows the desired output transition to be obtained on either the rising or falling slope of the input signal.

5.5.4 Pulse Shaper.

The pulse-shaper stage produces a short-duration, negative output pulse each time the rectangular input signal makes a positive excursion. C106 is charged by the emitter-follower action of Q105, on positive transitions of the input signal, to produce a large surge of transistor current. The charging impedance for the capacitor is very low and therefore the charging current diminishes rapidly to produce the desired short-duration output pulse; L101 aids in wave shaping. CR101 eliminates the positive output pulses that would otherwise be produced by the negative transitions of the input signal.

5.5.5 Scaler Circuit.

The scaler circuit consists of eight NPN transistor flip-flops cascaded to form a binary chain. The scaler counts the input trigger pulses. Each flip-flop circuit has a scale ratio of 2^n where n is the number of stages connected in cascade. Therefore, the scaler provides ratios in the binary sequence of 1 to 128.

The circuit operates on negative input trigger pulses. The first stage, flip-flop A, is driven by a negative input-trigger pulse from the pulse-shaper circuit. Succeeding stages are driven through a differentiating network.

For example, flip-flop B, has a differentiating network comprised of C403 and R413. In the reset state all the left-hand transistors on each flip-flop shown in Figure 7-6 are biased off by a 1.5-V supply, except flip-flop A, if the CYCLE COUNT switch is set to +1, allowing that stage to indicate a count of one input trigger.

Since the transistors on the left-hand side are biased off, the collector voltage is about +6 V. This positive voltage, in the case of flip-flop B, is applied through the voltage-divider circuit, comprised of R403 and R407, to the base of Q404, biasing the transistor on. On the second input-trigger pulse, Q402 conducts, causing the collector to go from a positive voltage to zero. This change in voltage is applied through the differentiating network of flip-flop B, resulting in a negative differentiated pulse. CR406 and CR407 steer the negative pulse to the proper transistor base. Since the base of Q404 is positive, forward biasing CR407, the pulse is steered to that base, cutting off Q404. This puts both transistors momentarily into the nonconducting state. Memory capacitors C410 and C411 cause the flip-flop to go to the opposite state.

The collector supply voltage is approximately 7 V and collector voltage swings are about 6 V in amplitude. A-1.5-V supply provides hold-off bias for the "off" transistors.

Fast reset from the reset generator is obtained by diode coupling between the reset bus and the desired flip-flop transistor. The CYCLE COUNT switch, S902, allows the option of resetting flip-flop A to either one of its states, so it either counts the first pulse or starts at the second pulse advancing the count by one, as explained in paragraph 5.4.1.

5.5.6 Main Flip-Flop.

Q108 and Q109 comprise the main flip-flop, which operates from a collector supply voltage of approximately 7 V. The circuit is a standard transistor binary circuit. Transistor pair Q110 and Q111 form a logical NAND gate to set the main flip-flop, and transistor pair Q106 and Q107 form a NAND gate to clear the flip-flop. Trigger pulses from the pulse shaper are applied to one of the series transistors of the gate pair. If the second transistor in the pair is nonconducting, the trigger pulses have no effect, but if the second transistor is in its conducting state, trigger pulses enable the gate, producing the desired transition in the main flip-flop. The output at the collectors of Q108 and Q109 swings between 0 and -7 V.

5.5.7 Reset-Pulse Generator.

The reset-pulse generator is a series gate comprised of PNP transistors Q112 and Q113 connected in series. Both transistors are normally biased on by a slight negative voltage at the base. Each transistor base is connected to one side of the main flip-flop. When the flip-flop changes its state, the flip-flop side going from the negative to a more positive voltage is differentiated by the RC network, comprised of R133 and C113, in the case of Q113, and R134 and C114, in the case of Q113, producing a positive pulse of short duration that turns off the transistor for a short time. When either Q112 or Q113 is turned off, a pulse of approximately 300 ns duration, going from +1.3 V to -2.5 V, is produced at the output of the circuit. A positive 20 V applied at the output, together with series diodes CR102 and CR103, establish the dc level of the output pulse at +1.3 V. The reset pulse is applied to the scaler resetting the appropriate scaler flip-flop.

5.5.8 On and Off Multivibrators.

The on and off monostable multivibrators (MM's) each consist of a flip-flop coupled to a regenerative pair. Each MM provides a variable time delay of 10μs to 10s. Since the operation of both MM's is the same, the operation of the on MM is described. The on MM flip-flop consists of Q118 and Q119, and the regenerative pair, Q120 and Q121. In the quiescent state Q119 is turned off and its collector voltage is approximately equal to the equivalent supply of 7 V.

Q120 and Q121 are nonconducting, since the timing-range capacitor, selected by the OUTPUT ON indicator-switch, is charged to approximately 7 V, and the base of Q120 is approximately 2 V, therefore backbiasing Q120 off by about 5 V.

When a negative transition occurs at the main flip-flop, it is differentiated by C121 and R154 and steered, via CR107, to the base of Q118, causing a state reversal. The turn-on of Q119 starts the discharge of the timing capacitor through the resistance network R164 and ON TIME potentiometer control R904.

After the selected time period, the timing capacitor voltage drops sufficiently to turn on Q120. The turn on of Q120 causes the turn on of Q121, and this regenerative pair latches up to charge the timing capacitor toward 7 V. The turn-on of Q121 produces a pulse that is steered via the differentiating network comprised of C125 and R162 and via CR108 to the base of Q119, causing the flip-flop to return to its stable state. As the timing capactior charges toward an equivalent source voltage of 7 V, the current through the regenerative pair diminishes to the point that regeneration can no longer be maintained, and Q120 and Q121 turn off, restoring the circuit to the initial and stable condition.

5.5.9 Gate-Driver And Sync-Pulse Amplifiers.

The gate-driver amplitier is placed between the main flip-flop and the on-off switch circuit to regulate the voltage level of the drive signal to the switch circuit. This amplifier is a differential pair whose basic operation is similar to that of the one described in paragraph 5.5.3. Balanced drive of this amplifier, i.e., inputs on both bases, improves the symmetry of waveshape of the on-off switch-circuit drive signal.

The sync-pulse amplifier is comprised of Q122 and a resistive divider formed by R171–R174. The resistor divider maintains the synchronization output voltage at -8 V when Q122 is not conducting. Q122, when saturated, shorts R172 to produce a sync-output voltage of +8 V. The gate-driver amplifier drives Q122 from its nonconducting to its saturated state, thus producing a sync-output voltage which alternates between +8 and -8 V.

5.5.10 On-Off Switch Circuit.

The on-off switch circuit consists of a cascade of two simple attenuators. Each attenuator consists of a series resistor and transistor (R204 and Q131, and R207 and Q132). The input signal is applied to the series combination, and the output signal is taken from Q132. The transistors are operated either in a nonconducting state or a saturated state.

In the former condition their impedance is extremely high and the input signal is passed with very little attenuation; in the latter state their impedance is low, approximately 10Ω, and the input signal is greatly attenuated. When the transistors are saturated the output voltage is raised above ground by an amount equal to the saturation drop of the transistors.

This slight offset voltage is not present when the transistors are not conducting and the effect, therefore, if uncorrected, is to produce a small change in level between the on and off states. Correction is obtained by injection of a very small current in the output of the on-off switch. When the transistors are not conducting, the current flows through the series resistors to produce a voltage drop equal to the saturation drop of the transistors, and when the transistors are saturated, the very small current has no effect. Zener diode CR115 provides a regulated source for the correction current, and PEDESTAL NULL control R901 allows adjustment of the correcting current.

When the switch transistors change state, small transients of a few tenths of a volt in amplitude and approximately 0.2 μs in duration are produced at the output due to a stored charge and capacity coupling of the base signal into the collector path. This undesirable signal is cancelled to some extent by TRANSIENT TRIM adjustment C135, which injects an out-of-phase transient to "buck" the undesirable signal. The BANDWIDTH TRIM adjustment, C136, also on the main circuit board, further reduces spurious response by placing a small capacitance between the signal output path and ground.

5.5.11 Lamp-Driver Multivibrator.

Operation of the lamp-driver multivibrator is best explained by neglecting the effect of R185 and C127 at the start. When the output signal is off, Q124 in the gate-driver-amplifier circuit is conducting collector current that produces a voltage drop in R178, turning on Q125. The emitter-collector voltage drop of saturated transistor Q125 is insufficient to turn on Q126. However, the "off" lamp in the collector circuit of Q125 is turned on, indicating the state of the on-off switch circuit.

When Q124 is not conducting, Q125 is biased off, producing a voltage at its collector that is applied to the base of Q126, through a voltage divider comprised of R187 and R189. This voltage is lower with respect to the collector voltage of Q126, thereby turning on Q126 and the "on" lamp.

Under normal operating conditions and in the absence of R185 and C127, the lamp bulbs would alternately conduct at a very rapid rate. Due to the nonlinear characteristic of the bulbs and the fact that their temperature cannot follow these rapid variations, a very dull lamp glow would result. With the addition of R185 and C127, however, either a turn-on or turn-off of Q126 will create a large regenerative current surge into the base of Q125 that will temporarily mask the effect of input current from the gate driver amplifier and hold the lamps temporarily in one conduction state.

After a short time, C127 will become fully charged and the lamp-driver multivibrator circuit will again become sensitive to drive from the gate-driver amplifier. The effect of the added regenerative feedback is to improve visibility of the lamps by causing them to conduct for a minimum time interval sufficient to allow the filament temperatures to reach full operating temperature.

5.5.12 Power Supplies.

Power supplies for the main and scaler circuit boards are unregulated, and the components, with the exception of the power transformer, are located on the respective circuit boards. The main-circuit-board power supply operates from a center-tapped power transformer secondary and has two full-wave rectifier circuits operating into RC filters to provide both +20- and -20-V supplies. The scaler-circuit power supply operates from a power transformer secondary with a full-wave rectifier and simple RC filter. The rectifiers of the scaler circuit supply are floating. The load is in series with two diodes in such a manner that the diodes provide the -1.5-V hold-off bias supply.

5.5.13 Switches.

Figure 7-7 shows the OUTPUT ON and OUTPUT OFF indicator-switch circuits. Both of these switches are standard, two-section, 12-position rotary switches. The OUTPUT ON indicator-switch, S904, selects output of the scaler circuit flip-flop associated with the number of cycles of input timing signal it is desired to initiate a tone burst. The switch also selects periods of time ranging from 10μs to10s that a tone burst will occur.

The OUTPUT OFF indicator-switch, S903, selects the output of the scaler circuit flip-flop associated with the number of cycles of input signal it is desired to turn off the tone burst. This switch also selects periods of time ranging from 10μs to 10s that it is desired to turn-off the tone burst.

Three capacitors (C906-C908) are associated with the OUTPUT ON switch circuitry to determine the time constant that controls the state of the on MM, hence the on-time of the tone burst in the timed mode of operation. The capacitors establish the 100-ms, 10-μs, and 1-s time ranges, respectively. The switch connects the appropriate capacitor to the on MM. The ON TIME control establishes the "on" times within these ranges by varying the value of the resistance (R904) that comprise the MM's RC circuit.

The OUTPUT OFF indicator-switch circuitry has three capacitors (C901-C903) which determine, in conjunction with the OFF TIME control, the RC time constant that controls the off MM in the timed mode of operation. This circuit operates the same way as the OUTPUT ON switch. The OUTPUT OFF switch circuitry also contains components that control single-burst operation. When the switch is set to SINGLE BURST, the MM is inhibited by +10 V applied to the emitter of Q116. When the SINGLE BURST pushbutton is pressed, C904, which is also part of the switch circuitry, discharges, applying a negative pulse to the emitter of Q116. This, in turn, acts to change the state of the OFF MM, enabling the main flip-flop clear gate and closing the on-off switch circuit for a time determined by the setting of the OUTPUT ON indicator-switch.

A lamp is located behind each switch dial to indicate that the output is on or off.

Service and Maintenance – Section 6

6.1 WARRANTY.

We warrant that each new instrument manufactured and sold by us is free from defects in material and workmanship, and that, properly used, it will perform in full accordance with applicable specifications for a period of two years after original shipment. Any instrument or component that is found within the two-year period not to meet these standards after examination by our factory, District Office, or authorized repair agency personnel, will be repaired, or, at our option, replaced without charge, except for tubes or batteries that have given normal service.

6.2 SERVICE.

The two-year warranty stated above attests the quality of materials and workmanship in our products. When difficulties do occur, our service engineers will assist in any way possible. If the difficulty cannot be eliminated by use of the following service instructions, please write or phone our Service Department (see rear cover), giving full information of the trouble and of steps taken to remedy it. Be sure to mention the serial and type numbers of the instrument.

Before returning an instrument to General Radio for service, please write to our Service Department or nearest District Office, requesting a "Returned Material Tag." Use of this tag will ensure proper handling and identification. For instruments not covered by the warranty, a purchase order should be forwarded to avoid unnecessary delay.

6.3 MINIMUM PERFORMANCE STANDARDS.

6.3.1 General.

The following paragraphs contain information to determine rapidly that the Tone-Burst Generator is performing within specifications. The procedures enable instrument-standards laboratories and equivalently equipped service facilities to perform routine calibration checks on properly functioning instruments and to determine that a repaired instrument has been restored to proper operation. These procedures are bench checks that require the use of only front-panel controls and externally available test points (i.e., instrument disassembly is neither required nor recommended).

Table 6-1 lists the recommended test equipment for a minimum performance check and adjustments.

The following checks are included in this paragraph to determine that the instrument is operating properly:

1. Pedestal null and dc level
2. Switching transient
3. Bandwidth and current limiting
4. Feedthrough
5. Triggering
6. Cycle count
7. Distortion
8. Direct external control.

6.3.2 General Instructions.

Observe the following general rules when performing the checks:

a. Allow one-half hour for instrument warm-up.

b. When specified in the procedure, load the 1396's output with a 120-pF capacitive load. The oscilloscope-probe and patch-cord capacitance must be taken into account; therefore, use the recommended 10X Tektronix voltage probe and a suitable capacitor connected across the SIGNAL OUTPUT binding posts.

Table 6-1
TEST EQUIPMENT FOR MINIMUM
PERFORMANCE CHECKS AND ADJUSTMENT PROCEDURES

Instrument	Requirements	Recommended*
Oscilloscope	20-MHz bandwidth	Tektronix Type 454, 543B, or 544 with suitable plug-in unit, where required.
Oscilloscope Plug-in Unit	20-MHz bandwidth, 50mV/cm deflection factor.	Tektronix Type 1A1 or 1A2.
Voltage Probe	10X attenuation.	Recommended 10X probe for oscilloscope. (A check and an adjustment require a capacitor to be attached to the SIGNAL OUTPUT terminals of the 1396 to form, together with the probe and patch cord, a 120-pF capacitive output loading.)
Distortion Analyzer	Measure total distortion down to 0.1%, 1 kHz to 10 kHz.	Hewlett-Packard Model 334A.
Oscillator (required for distortion check)	14-V pk-pk output; frequency to 10 kHz; distortion 0.05% or less.	GR Type 1309.
Oscillator	20-V pk-pk output; frequency to 1 MHz.	GR Type 1310.
Pulse Generator	9-V pk-pk output; frequency to 1 MHz; 0.5μs pulse duration.	GR Type 1217 and associated Power Supply (Type 1201) or GR Type 1340.
Battery	1.5 V.	———
Patch cords	As required.	Refer to Table 1-4.

*Or equivalent

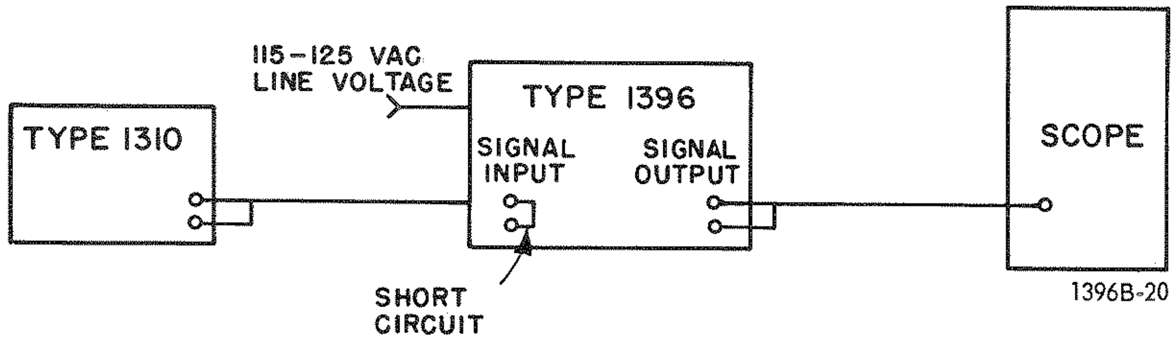


Figure 6-1. Minimum performance standards test setup.

6.3.3 DC Level and Pedestal Null.

a. Establish the test setup shown in Figure 6-1, connecting the Type 1310 Oscillator, or equivalent, to the rear-panel EXT TIMING connector and short-circuiting the front-panel SIGNAL INPUT binding posts with a suitable strap or wire. If available, use a Tektronix Type 454 oscilloscope with a Type P6047 voltage probe for this check and the switching transient check, paragraph 6.3.4.

b. Set the 1396's switches and controls to the following positions:

OUTPUT ON	1 CYCLE
OUTPUT OFF	1 CYCLE
CYCLE COUNT	NORMAL
SLOPE	Minus (-)
TIMING	EXT
Line Voltage Selector	115-125

c. Set the 1310's controls to obtain a 1-kHz, 2-V pk-pk signal for application to the 1396.

d. Turn-on the 1396 according to Section 3 of this instruction book.

e. Adjust the LEVEL control for proper instrument operation as indicated by the alternate lighting of the OUTPUT ON and OUTPUT OFF indicator-switch dials.

f. Set the oscilloscope VOLTS/DIV control to 5mV/cm and TIME/DIV control to 0.5 ms/cm and establish an oscilloscope ground reference.

g. Observe that a straight line (pedestal null) appears at the ground level (dc zero) established on the oscilloscope. If a straight line does not appear at the dc level, perform the pedestal null and/or dc zero adjustments in paragraph 6.8.

6.3.4 Switching Transient.

a. Use the test setup of paragraph 6.3.3. However, connect a capacitor across the SIGNAL OUTPUT binding posts to form, together with the voltage probe and patch cord, a 120-pF capacitive output load.

b. Set the switches and controls as specified in step b of paragraph 6.3.3.

c. Set the controls on the 1310 Oscillator to obtain a frequency of 1 MHz, 2 V pk-pk.

d. Set the oscilloscope VOLTS/DIV control to 5mV/cm and TIME/DIV Control to .05 s/cm.

e. Observe on the oscilloscope that the "on" time and "off" time transients do not exceed the dimensions shown in Figure 6-2. The oscilloscope horizontal position control must be used to observe both transients. The "off" transient pulse width should be equal to or less than that of the "on" transient. The output "on" transient observed on the oscilloscope is the "smoother" waveform. Perform the transient-trim and bandwidth adjustment procedure in paragraph 6.8, if the proper transient waveforms are not observed.

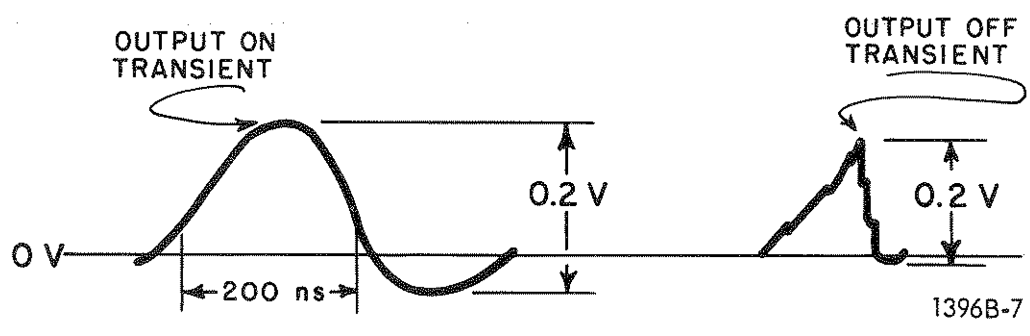


Figure 6-2. Typical output "on" and "off" switching transients.

6.3.5 Bandwidth and Current Limiting.

a. Use the test setup specified in paragraph 6.3.3. However, remove the short circuit from the front-panel SIGNAL INPUT binding posts and apply a 1-MHz, 10-V pk-pk input signal to the rear-panel SIGNAL INPUT connector.

b. Set the switches and controls as specified in paragraph 6.3.3, except for the following:

1. Type 1396:	OUTPUT ON to CONT, TIMING to INT (NORM).
2. Type 1310:	1-MHz, 10-V pk-pk output.
3. Oscilloscope:	VOLTS/DIV to 0.2V/cm, TIME/DIV to 0.5ms/cm.

c. Observe on the oscilloscope that the output of the 1396 is 10 V pk-pk (+1, -0.5).

d. Adjust the 1310 Oscillator for a 1-MHz, 10-V pk-pk output.

e. Set the oscilloscope TIME/DIV control to 0.5μs/cm and observe that the output of the 1396 is greater than 8 V pk-pk.

f. Connect a 50-Ω resistor across the SIGNAL OUTPUT terminals of the 1396.

g. Adjust the output of the 1310 until the output waveform of the 1396 displayed on the oscilloscope begins to become distorted. Observe that the amplitude of the displayed waveform is 2.5 V pk-pk, or greater.

h. Adjust the 1310 for a 2-MHz, 10-V pk-pk output; set the oscilloscope TIME/DIV switch to 0.2μs/cm and repeat step g.

i. Observe that distortion of the displayed waveform begins at 1.5 V pk-pk, or greater.

6.3.6 Feedthrough.

a. Use the test setup specified in paragraph 6.3.3. However, remove the short circuit from the SIGNAL INPUT binding posts and apply a 1-MHz, 20-V pk-pk input signal to the rear-panel SIGNAL INPUT connector and connect the output of the 1396 to the input of the oscilloscope with a GR Type 274-NP patch cord, or equivalent. (See Table 1-4.)

b. Terminate the patch cord at the oscilloscope input with a 50-Ω resistor.

c. Set the switches and controls as specified in paragraph 6.3.3, except for the following:

1. Type 1396:	OUTPUT OFF to SINGLE BURST, TIMING to INT (NORM) (OUTPUT ON should be 1 CYCLE).
2. Type 1310:	1 MHz, 20-V pk-pk output.
3. Oscilloscope:	VOLTS/DIV to 5mV/cm, TIME/DIV to 0.5μs/cm.

d. Observe on the oscilloscope that the signal feedthrough amplitude is less than 20 mV pk-pk.

6.3.7 Triggering.

a. Use the test setup in paragraph 6.3.3. However, remove the short circuit from the SIGNAL INPUT binding posts and apply a 2 MHz, 0.6-V pk-pk signal input to the rear-panel SIGNAL INPUT connector. Use the voltage probe and patch cord to connect the 1396's output to the oscilloscope input.

b. Set the switches and controls as specified in paragraph 6.3.3, except as follows:

1. Type 1396:	TIMING to INT (NORM) (OUTPUT ON and OFF should be 1 CYCLE).
2. Type 1310:	2-MHz, 0.6-V pk-pk output.
3. Oscilloscope:	VOLTS/DIV to 20 V/cm, TIME/DIV to 2μs/cm.

c. Adjust the TRIGGER LEVEL control and observe on the oscilloscope that the output turns on and off.

d. Connect the 1310 Oscillator, or equivalent, to the EXT TIMING connector on the rear panel and set the TIMING switch to EXT.

e. Repeat step c. In this case, only on and off switching will occur; there will be no tone-burst output.

6.3.8 Cycle Count and Timing.

a. Use the test setup specified in paragraph 6.3.3. However, remove the short circuit from the SIGNAL INPUT binding posts and apply a 100 kHz, 10-V pk-pk signal to the front- or rear-panel connector(s). Also, connect the other oscilloscope channel to the SIGNAL INPUT connector(s).

b. Set the switches and controls as specified in paragraph 6.3.3, except as follows:

1. Type 1396:	TIMING to INT (NORM)
2. Type 1310:	100 kHz, 10-V pk-pk output

3. Oscilloscope: Type 1396 input channel; VOLT/DIV to 2V/cm TIME/DIV to 20μs/cm

Type 1396 output channel; VOLT/DIV to 2V/cm TIME/DIV to 20μs/cm

c. Synchronize the oscilloscope with the synchronization signal from the SYNC OUTPUT connector.

d. Observe on the oscilloscope that the output of the 1396 is on one cycle and off one cycle.

e. Set the SLOPE switch to + and observe that the output is switched on and off with the positive-going slope of the input signal.

f. Set the SLOPE switch to minus (-).

g. Set the CYCLE COUNT switch to +1 and observe that the on and off intervals extend for two cycles, or periods, of input signal.

h. Set the CYCLE COUNT switch to NORMAL.

i. Set the OUTPUT ON switch to 2 CYCLES and observe that the output "on" interval is two cycles of input signal and the output "off" interval extends for one cycle of input signal.

j. Set the OUTPUT OFF switch to 2 CYCLES and observe that the output on and output off intervals each extend for two cycles of input signal.

k. Set the COUNT switch to +1 and observe that the on and off periods are extended one cycle of input signal (i.e., on and off for three cycles of input signal).

l. Set the CYCLE COUNT switch to NORMAL.

m. Repeat steps i and j, except advancing the OUTPUT ON and OFF switches one position each and observing the appropriate output on and off intervals until switch position 128 CYCLES has been checked.

NOTE

After 16 cycles are observed it will be difficult or impossible to count the cycles for the remaining switch positions with the oscilloscope. Therefore, observe that the on and off interval "blocks" shown on the oscilloscope for these switch positions double when the appropriate switch is advanced one position. It is not necessary to set the CYCLE COUNT switch to the +1 position for the remaining cycle count checks.

n. Check the output- on and -off timed intervals by setting the OUTPUT ON and OFF and ON and OFF TIME controls to a convenient setting and applying to the instrument a signal whose period is much smaller than the intervals established with the controls. Observe on the oscilloscope that the intervals are approximately those established with the controls.

o. Check that the OUTPUT ON and OFF and ON and OFF TIME control time-ranges (10 μs-1 ms, 1 ms-100 ms, 0.1 s to 10 s) overlap (i.e., there is continual time coverage from 10 μs to 10 s) by setting the controls to the appropriate positions and observing the intervals on the oscilloscope. If the timed interval is not accurate, refer to the switch replacement procedure in paragraph 6.10 which describes the adjustment of timed intervals.

p. Set the OUTPUT OFF switch to SINGLE BURST and the OUTPUT ON switch and ON TIME control to various positions and press the SINGLE BURST pushbutton switch. Observe that a tone burst occurs for the interval determined by the OUTPUT ON switch and ON TIME control.

6.3.9 Distortion.

a. Establish the test setup shown in Figure 6-3.

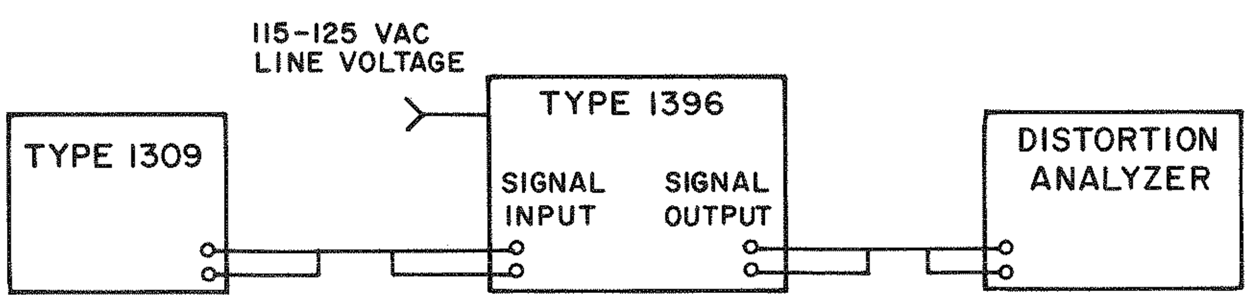


Figure 6-3. Distortion check test setup.

b. Set the switches and controls on the 1396 to the following positions:

OUTPUT ON	CONT
OUTPUT OFF	1 CYCLE
CYCLE COUNT	NORMAL
SLOPE	Minus (-)
TIMING	INT (NORM)
Line-Voltage Selector	115-125

c. Set the 1309's controls to obtain a 1-kHz, maximum output (14-15 V pk-pk) signal for application to the 1396.

d. Set the Distortion Analyzer controls for an input frequency of 1 kHz.

e. Turn-on the 1396 according to Section 3 of this instruction book and observe on the distortion analyzer that the distortion is less than 0.2%.

f. Change the 1309's output frequency to 10 kHz, maintaining a maximum output.

g. Observe that the signal distortion is less than 0.2%.

6.3.10 External Timing.

a. Establish the test setup shown in Figure 6-4. Connect the Type 1217 Unit Pulse Generator to the 1396's rear-panel EXT TIMING CONNECTOR and to one of the oscilloscope channels, and connect a 1.5-V battery across the SIGNAL INPUT binding posts of the 1396, as shown in Figure 6-4.

b. Set the 1396's controls and switches as follows:

OUTPUT ON	Any position
OUTPUT OFF	Any position
CYCLE COUNT	NORMAL
SLOPE	Minus (-)
TIMING	EXT DIR
Line-Voltage Selector	115-125.

c. Set the 1217's controls to obtain an output PRF of 1 MHz, 9 V pk-pk, of 0.5-μs duration.

d. Set the oscilloscope controls as follows:

CHANNEL 1;	VOLTS/DIV to 0.5V/cm, TIME/DIV to 0.2μs/cm
CHANNEL 2;	VOLTS/DIV to 50mV/cm, TIME/DIV 0.2μs/cm

e. Turn-on the 1396 according to Section 3 of this instruction book and observe on the oscilloscope that the switching action is a replica of the external timing signal input.

6.4 COMPONENT LOCATIONS.

All the circuits for the 1396 are on two circuit boards. The main circuit board, occupying the lower position in the instrument, contains all the circuits except the binary scaler. The binary scaler circuit is on the upper circuit board. Figure 6-5 shows the locations of internal adjustments and various components. Table 6-2 lists the locations of components according to reference designation groupings.

Table 6-2
COMPONENT LOCATIONS

Component Numbers	Location
100 thru 299	Main Circuit Board
400 thru 499	Scaler Board
800 thru 899	Rear Panel
900 thru 999	Front Panel

Figures 7-1 to 7-6 identify the exact locations of the components on the circuit boards and panels.

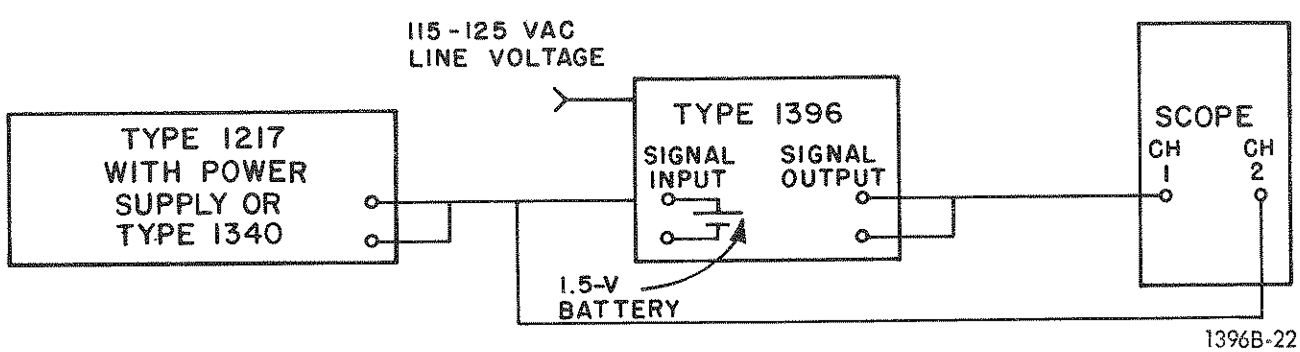


Figure 6-4. Direct external timing test setup.

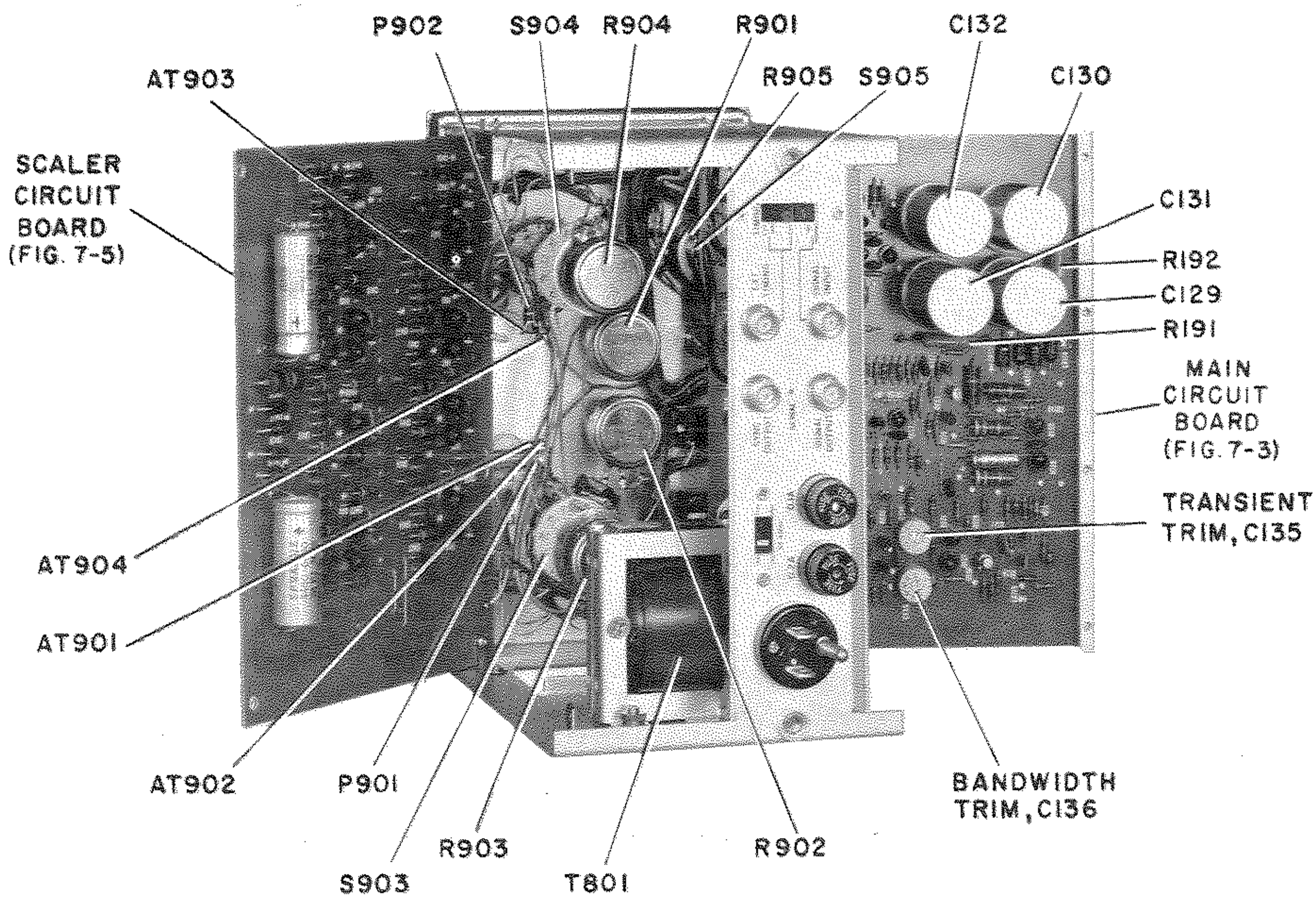


Figure 6-5. Interior view of the Type 1396.

6.5 CHASSIS REMOVAL-REPLACEMENT.

Perform the following steps to gain access to the components and internal adjustments:

a. Loosen the two captive screws on the rear panel and carefully slide the chassis out of the cabinet.

b. Set the chassis on its side and remove the two screws at the rear of each circuit board that secure the board to the frame.

c. Swing the boards away from the chassis as you would the covers of a book. (See Figure 6-5.)

To replace the chassis, reverse the above procedure; however, take care not to pull any cables or wires when sliding the chassis into the cabinet. Use a screwdriver or suitable tool to straighten the front gasket, if necessary.

6.6 SERVICING ETCHED-CIRCUIT BOARDS.

The 1396 has two etched circuit boards. The boards have the components on one side and the circuitry on the opposite side. A layer of metal plated through the component connection holes provides the electrical connection to the circuitry.

When removing or replacing components, use a low-heat soldering iron and a small-diameter rosin core solder. Do not subject the components or boards to excessive or prolonged heat. Components can be removed by placing the soldering iron on the component lead on either side of the board and pulling up on the lead. If a component is obviously faulty or damaged, clip the leads close to the component and then remove the leads.

The component lead hole should be cleaned before inserting a new lead. Heat the solder in the hole, quickly remove the soldering iron, and insert a pointed non-metallic object such as a tooth pick.

Shape the new component leads, insert them in the holes, reheat with the iron, and add solder as necessary to form a good electrical connection. Clean any excess flux from the connection and adjoining area.

6.7 TEST POINTS.

Signal measurements can be made at anchor terminals (AT's) on the circuit boards and front and rear panels. The terminals are identified in the illustrations and schematics in Section 7. AT's on the circuit boards are clearly labeled on the foil side of the boards; the AT numbers on the boards are not prefixed by letters.

Lamp holders P901 and P902 each have two AT's not identified by legends. AT902 and AT904 are at the orange- or blue-wire connection to the contact spring on the holder. AT901 and AT903 are at the orange and white-wire connection to the contact clip in the holder.

6.8 ADJUSTMENTS.

The following adjustment procedures should be performed only when it has been definitely established that the Tone-Burst Generator is out of adjustment as determined by symptoms during operation, by performance checks, or after corrective maintenance has been performed.

6.8.1 Adjustment Information.

Load the Type 1396's output with a 120-pF capacitive load for the bandwidth and transient-trim adjustment procedure. The oscilloscope-probe and patch-cord input capacitance must be taken into account when establishing the output load. If available, use a Tektronix Type 454 oscilloscope with a Tektronix Type P6047 voltage probe. Otherwise use an oscilloscope and probe recommended in Table 6-1. The Type P6047 probe requires a 110-pF capacitor connected across the 1396's SIGNAL OUTPUT binding posts to establish a 120-pF capacitive loading.

Allow one-half hour for instrument warm-up before making any adjustments.

Provide a sinusoidal input signal for all the procedures. The oscilloscope may be synchronized internally, if desired.

6.8.2 Pedestal-Null Adjustment.

a. Connect an oscilloscope (refer to paragraph 6.8.1 for details) to the SIGNAL OUTPUT terminals.

b. Short circuit the front-panel SIGNAL INPUT terminals with a strap or a wire and set the rear panel TIMING switch to EXT.

c. Turn on the Type 1396 according to paragraph 3.1, applying a 1-kHz, 2-V pk-pk sinusoidal signal to the rear-panel EXT SIGNAL connector.

d. Set the SLOPE switch to minus (-) and the TRIGGER LEVEL control for proper operation.

e. Set the OUTPUT ON and OUTPUT OFF switches to 1 CYCLE and observe the oscilloscope. If a one-cycle on and a one-cycle off pulse appears, adjust the PEDESTAL NULL adjustment until the pedestal is nulled out and a straight line appears on the oscilloscope display (i.e., the peak of each half cycle must be aligned until only a straight line appears on the display).

f. After nulling out the pedestal, perform the dc zero adjustment. Do not change any connections or switch settings.

6.8.3 Dc Zero Adjustment.

Perform the pedestal-null adjustment. After performing step e of the pedestal-null adjustment, find the dc zero level of the oscilloscope and compare it to the level obtained in step e. Adjust DC ZERO until both levels are the same.

6.8.4 Bandwidth and Transient Trim.

a. To gain access to the bandwidth-trim adjustment, C136, and the transient-trim adjustment, C135, remove the chassis from the cabinet and swing out the main (bottom) circuit board according to paragraph 6.5. Figure 6-5 shows the locations of the adjustments.

b. Short circuit the SIGNAL INPUT terminals with a strap or wire, set the rear-panel TIMING switch to EXT, and connect the instrument to the oscilloscope according to the instructions in paragraph 6.8.1.

c. Turn on the Type 1396 according to paragraph 3.1, applying a 1-MHz sinusoidal signal to the rear-panel EXT TIMING connector.

d. Set the OUTPUT ON and OUTPUT OFF indicator-switches to 1 CYCLE and observe the output. The pulse width of the output "on" transient that occurs when output "on" switching takes place should be 200 ns or less and the voltage 0.2 V pk-pk (typical). The pulse width of the output "off" transient will be less than 200 ns if the output "on" transient pulse width is less than 200 ns (Figure 6-6). The output "on" transient is identified as the "smoother" waveform.

e. If necessary, adjust C136 to obtain the correct amplitudes of both transients.

f. If necessary, adjust C135 to obtain the correct pulse-width of the output "on" transient.

6.9 TROUBLE ANALYSIS.

Table 6-3 lists the recommended equipment for troubleshooting the instrument. Table 6-4 lists most of the symptoms of malfunctions that can occur in the instrument, and the circuit(s) to be checked for isolating the fault. Table 6-5 contains the circuit test and test data for isolating the fault to the circuit and circuit component(s).

Obvious checks that should be performed before troubleshooting are not listed in the tables. These include power and power connections, fuses, lamps, etc. The instrument should also be inspected for broken and shorted wiring and damaged or faulty components before attempting to troubleshoot.

Use the panel controls whenever possible to determine the exact mode or portion of a mode that has failed. The controls can also be used to isolate faults. For instance, the OUTPUT ON and OUTPUT OFF indicator-switches can be used to isolate a fault to a scaler circuit flip-flop, to the main flip-flop and reset generator circuit, and the on and off monostable multivibrators.

Table 6-3
RECOMMENDED TEST EQUIPMENT FOR TROUBLESHOOTING

Instrument	Requirements	Recommended*
Volt- Ohm-Millimeter	–	Triplett Type 630-NA.
Oscilloscope	20-MHz bandwidth.	Tektronix Type 454, 543B, or 544 with suitable plug-in, where required.
Oscilloscope Plug-in Unit	20-MHz bandwidth; 50 mV/cm deflection factor.	Tektronix Type 1A1 or 1A2.
Oscillator	10-V pk-pk output; frequency to 10 kHz.	GR Type 1310.
Pulse Generator	1-kHz PRF, 10-V pk-pk square-wave output.	GR Type 1217 with power supply or GR Type 1340.

*Or equivalent

6.10 REMOVAL AND REPLACEMENT OF CONTROLS.

6.10.1 Output On-Off Controls.

Removal. Perform the following steps to remove and replace the OUTPUT ON, ON TIME, OUTPUT OFF, and OFF TIME controls:

a. Remove the cabinet from the chassis according to the procedure in paragraph 6.5.

b. Set the particular OUTPUT control to 4 CYCLES and set the chassis on its side so the switch wafers can be observed.

c. Remove the screws at the rear of the top circuit board and swing the board out.

d. Observe from between the circuit board and the front panel, the front of section 1 of the switch. This is the wafer and side nearest the front panel. Note that the switch

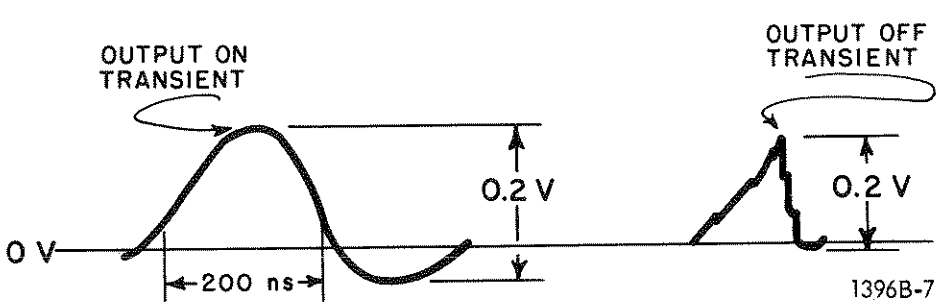


Figure 6-6. Typical output transients.

wiper is at position 103 F (not shown on the switch; refer to Figure 7-7, if necessary, to identify the switch contacts), opposite position 103 R at which the red and white wires are connected. This position will serve as a reference when replacing the dial to insure that the dial is set to the correct position. The TIME vernier dial need not be prepositioned before removal.

Table 6-4
FAULT INDICATIONS

Symptom	Check
No output in any mode of operation	First check the signal at the SYNC OUTPUT connector. If the proper signal is present (approx. +8V when the output is on, approx. -8V when the output is off), check the circuits between the gate-driver amplifier circuit and the output. (tests No. 9 through 14, Table 6-5). If operating properly, check the circuits between the input and the gate-driver amplifier circuit (tests No. 4 through 8, Table 6-5).
Output remains on in cycle count and timed modes.	Check the main flip-flop, input-trigger circuit, pulse-shaper circuit, gate-driver amplifier circuit, on-off switch circuit, and panel switches.
Unit operates in the cycle-count mode but not the timed mode, or timed-mode operation is erratic.	Check the on-off monostable multivibrators and OUTPUT ON, ON TIME, OUTPUT OFF, and OFF TIME indicator-switches and controls.
Unit operates in the timed mode but not the cycle-count mode, or the cycle-count mode of operation is erratic.	Check the reset generator, scaler circuit and power supply, and OUTPUT ON and OFF indicator-switches.
A single tone-burst can not be produced.	Check the off monostable multivibrator at anchor terminal 116 on the main circuit board, and SINGLE BURST and OUTPUT OFF switches.
A continuous output cannot be produced.	Check on and off monostable multivibrators and OUTPUT ON indicator-switch.

e. Hold the chassis securely and grasp the knob firmly with the fingers. Pull the knob straight away from the dial.

CAUTION

Do not pull on the dial to remove a dial/knob assembly. Always remove the knob first. Do not use a screwdriver or other instrument to pry off the knob if it is tight, since this might mar or crack the dial. Do not lose the spring clip in the knob when it is removed.

f. Remove the setscrew from the bushing; use a hex socket-key wrench.

g. Remove the bushing and TIME dial.

NOTE

To separate the bushing from the knob, if for any reason they should be combined off the instrument, drive a machine tap a turn or two into the bushing for sufficient grip for easy separation.

h. From the next bushing, remove the two setscrews using a hex socket-key wrench; remove the bushing and dial.

i. If the switch is to be removed, remove the dress nut and washer under the dial; the switch should lift out when the attached wires are unsoldered.

Replacement.

a. Install the OUTPUT ON or OUTPUT OFF dial over the dress nut and washer. Make sure the dial is set to 4 CYCLES, and that the switch wiper is in the position described in step d. in paragraph 6.10.1 (Removal).

b. Install the bushing and fasten with the two setscrews.

c. Set the OUTPUT ON or OUTPUT OFF dial to x10 mSEC.

d. Turn-on the instrument according to the procedure in Section 3, applying a 10-kHz signal to the SIGNAL INPUT terminals.

e. Connect an oscilloscope to AT109 if the OFF TIME dial is being replaced, or to AT110 if the ON TIME dial is being replaced. These terminals are on the main circuit board. At these terminals the oscilloscope measures the outputs of the on or off monostable multivibrators, giving an accurate on or off time measurement. The positive voltage duration indicates the on or off times. (See Figure 5-4.)

f. Adjust the ON TIME or OFF TIME control handle (before replacing the knob), so that a 10-ms time duration is derived. This should be equivalent to a combination setting of the OUTPUT ON or OUTPUT OFF controls at x10 mSEC and the ON TIME or OFF TIME vernier dial at 1.0.

g. When the time duration is obtained, install the vernier dial so that the reading on the dial (1.0), together with the setting of the OUTPUT ON or OUTPUT OFF switch, corresponds to the time duration observed on the oscilloscope. The tick mark on the vernier TIME dial and the line between the time reading on the OUTPUT switch should be aligned accurately.

h. Secure the dial with the bushing and setscrew. Make sure the TIME dial does not move when tightening the screw.

6.10.2 Trigger Level and Slope Controls.

To remove the knobs, note the positions of the controls, then pull both knobs off, one at a time. Do not lose the spring clips in the knobs. Release the bushings and remove the dress nut and washer. To replace the knobs, reverse the removal procedures, placing the retention spring opposite the setscrew.

6.11 LAMP-REPLACEMENT PROCEDURE.

To replace a burnt-out dial lamp, slide the metal clip off the back of the lamp holder and remove the lamp. Insert a new lamp (Chicago Miniature Lamp Works, No. 327 lamp; refer to the Parts Listing), and replace the clip.

6.12 FRONT-PANEL FINISH.

If the front panel is marred or scratched, retouch with a light gray color, conforming with Federal Standard 595 (gray, 26492).

Table 6-5
TEST TABLE

POWER SUPPLY **Make power supply measurements with no signal input or output connections other than line voltage.**

Test No.	Test	Measurement Between	Nominal Voltage	If Test Fails
1.	LINE VOLTAGE	Contact points in center of fuseholder caps	115, 220 or 230 V ac	Check fuses. See specifications for power and line-voltage requirements.
2.	MAIN CIRCUIT-BOARD POWER SUPPLY			
	Input to Rectifiers	AT125 & AT125	50 V ac rms	Check POWER ON-OFF switch and power transformer.
	Input to Filters	Cathode CR111(+) and anode CR114	59 V dc & 123 V ac rms	Check CR111-CR114.
	Output	AT106 & ground	+20 V dc	Check R191, C129, C131 and C140.
		AT107 & ground	-20 V dc	Check R192, C130, C132, and C141.
	Output Ripple	AT106 & ground AT107 & ground	Approximately 30 mV pk-pk	Check above components and line voltage.
3.	SCALER CIRCUIT-BOARD POWER SUPPLY			
	Input to Rectifiers	Cathode CR427 & anode CR428	14 V ac rms	Check POWER ON-OFF-switch and power transformer.
	Input to Filters	Cathode CR426 & anode CR429	15.5 V dc and 34 V ac rms	Check CR428-CR429.

Table 6-5 (Cont'd)
TEST TABLE

Test No.	Test	Measurement Between	Nominal Voltage	If Test Fails
	Output	Junction R425, C425 & ground	+6 V dc	Check R471, C424, and 425.
		Anode CR429 & ground	-1.5 V dc	Check CR430 and CR431, C424 and C425.
	Output Ripple	Junction R471, C425 & ground	Approximately 20 mV pk-pk	Check above components.
		Anode CR429 & ground	Approximately 5 mV pk-pk	Check above components.

For the following tests, apply a 10 kHz, 10-V pk-pk sine wave signal to the INPUT terminals. Set the panel controls and switches to the following positions:

INPUT

- TIMING to INT (NORM)
- SLOPE to +
- TRIGGER LEVEL to 0
- OUTPUT ON to 2 CYCLES
- OUTPUT OFF to 2 CYCLES
- CYCLE COUNT to NORMAL
- POWER to ON.

Small aberrations appearing on waveforms are not reproduced in this table.

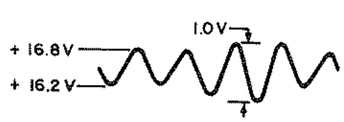
Test No.	Test	Measured To Ground From	Typical Voltage Waveform	If Test Fails
4.	INPUT			
	Input Signal	AT128		Check cables and connectors.
	Input Amplifier	Q127 collector		Check associated components.
		Q128 collector		Check associated components, Q129, and Q130.
		Q129 collector		Check associated components and Q130.

Table 6-5 (Cont'd)
TEST TABLE

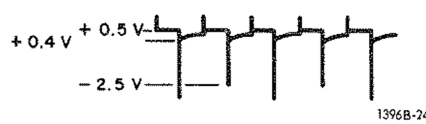
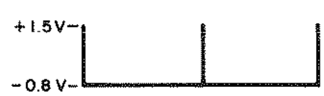
Test No.	Test	Measured To Ground From	Typical Voltage Waveform	If Test Fails
5.	INPUT-TRIGGER CIRCUIT			
		Q101 collector		Check R203, R105, Q102 and TIMING switch.
		Q102 collector		Check R905, R106, R109-R111.
		AT102		Check Q104, R106, R104, and R107.
		AT103		Check Q103, R105, R103, and R107.
6.	PULSE-SHAPER CIRCUIT			
	Input	Q105 base		Check AT's 102 and 103 above and R113, R114 and SLOPE switch.
	Output	Q105 collector		Check Q105, R115, L101, R116 and CR101.
7.	MAIN FLIP-FLOP			
		Q106 or Q110 base		Check R118, R119 and scaler circuit or R131, R132 and scaler circuit.
		Q107 or Q111 base		Check Q106 or Q110, and R130 and C112, or R117 and C107.
		Q108 or Q109 collector		Check R121, R124, C110, R126, R128 and R129 for Q108; R122, R123, C109, R125, R127, and R129 for Q109; and C111.
8.	RESET-PULSE GENERATOR			
	Input	Q112 base		Check main flip-flop, R133, and C113.

Table 6-5 (Cont'd) TEST TABLE

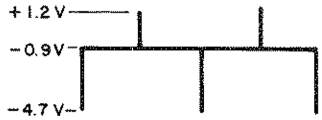
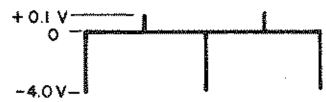
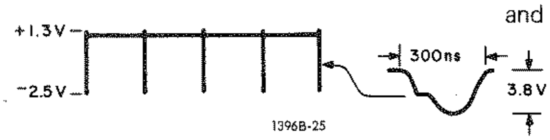
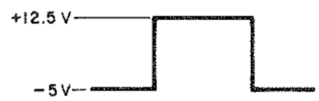
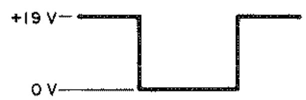
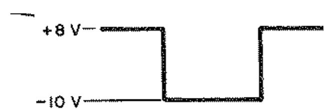
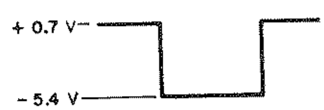
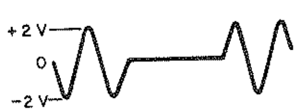
Test No.	Test	Measured To Ground From	Typical Voltage Waveform	If Test Fails
		Q113 base		Check main flip-flop, R134, C114, and Q112.
		Q112 collector		Check Q112, Q113, and R135.
		Q113 collector		Check Q113 and R135.
	Output	AT112		Check CR102, CR103, R136, and C115
9.	GATE-DRIVER AMPLIFIER			
		Q123 collector		Check associated components, main flip-flop, and Q124.
		Q124		Check R178 and R180-R183.
10.	SYNC-PULSE AMPLIFIER			
	Output	AT121		Check gate-driver amplifier Q122, R231, C126, and R171-R174.
11.	ON-OFF SWITCH CIRCUIT			
		Q131 base & Q132 base		Check gate-driver amplifier, Q1312 Q132, R205, and R206.
12.	OUTPUT AMPLIFIER			
	Input	Q133 base		Check on-off switch circuit, R204, R207, R901 (PEDESTAL NULL adjustment; see below), and R212.

Table 6-5 (Cont'd)
TEST TABLE

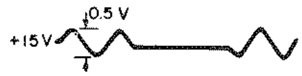
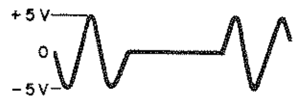
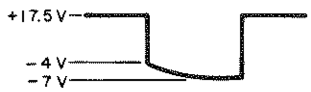
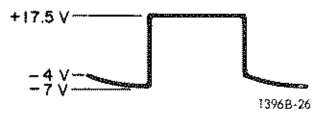
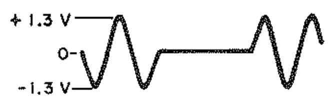
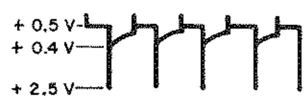
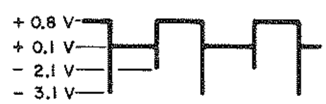
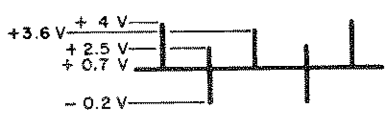
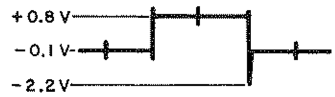
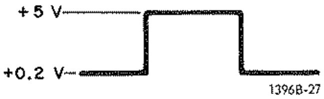
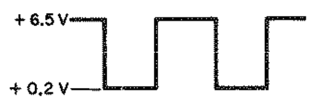
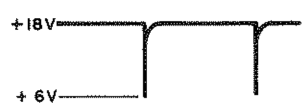
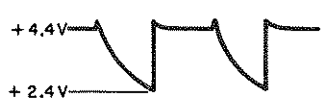
Test No.	Test	Measured To Ground From	Typical Voltage Waveform	If Test Fails
		Q133 collector		Check R902 (DC ZERO adjustment; see "Adjustment Procedures"), R213, and R216.
	Output	AT137		Check Q134-136, R214, R217, R218, C138 and R219-R223.
13.	LAMP-DRIVER MULTIVIBRATOR			
		Q125 collector		Check gate-driver amplifier, CR110, R185-R187, R189 and Q126.
		Q126 collector		Check R232, R190, R198, C128, and R186.
14.	PEDESTAL NULL	AT133		Check R209, CR115, R211, R212, and R901. (Refer to Pedestal-null and transient-trim adjustments in "Adjustment Procedures.")
15.	SCALER	For the scaler circuit tests, set the OUTPUT ON and OFF switches to 128 CYCLES. All other switch settings and the input signals should be the same as those of the "Input" tests above.		
	FIRST FLIP-FLOP			
	Input	AT419		Check pulse-shaper circuit.
		Q402 base		Check CR401 and 402, Q401, Q402, R402-R407, C401, and C402.
	Output	Q402 collector		Check above components.
	SECOND FLIP-FLOP			
	Input	Cathode CR406 or CR407		Check C403, R413, and R466.

Table 6-5 (Cont'd)
TEST TABLE

Test No.	Test	Measured To Ground From	Typical Voltage Waveform	If Test Fails
		Q404 base		Check CR406 and 407, Q403, R409-R415, C404, and C405.
	Output	Q404 collector		Check above components.
	To check all eight flip-flops in the scaler circuit, set the OUTPUT ON and OFF switches to 128 CYCLES and measure the voltage at the collectors of Q401 to Q416 (either the odd-or even-numbered transistors of the flip-flops are sufficient). The other switch settings should be as stated for the "Input" tests above. The input and output waveforms for flip-flops 3-8 are of the same amplitude as those for flip-flop 2. However, the output pulse width of each succeeding flip-flop should be twice the period of the preceding flip-flop. Check components of the failed flip-flop.			
	TIMING	To check the timing circuitry, set the OUTPUT ON and OFF switches to x100 MSEC and the ON and OFF TIME controls to 1. All other switch settings and the input signal should be the same as in the "Input" tests above. The waveform amplitudes shown are the same for OUTPUT ON and OFF switch setting of x10 MSEC and 1 SEC and ON and OFF TIME control setting of 1. The pulse width, however, will vary according to the time established by the setting of the switches and controls.		
16.	MONOSTABLE MULTIVIBRATOR			
		Q114 or Q118 collector		Check associated components.
		Q115 or Q119 collector		Check associated components.
		Q116 or Q120 collector		For Q116 check the OFF TIME control circuit, OUTPUT OFF switch, R147 and Q117. (See measurement at AT116.) For Q120 check the ON TIME control circuit, OUTPUT switch, R164 and Q121. (See measurement at AT120.)
		Q117 or Q121 collector		For Q117 Check CR106 and R148-R153. For Q121 check CR109 and R165-R170.
		AT116 or AT120		Check OUTPUT OFF switch circuit or OUTPUT ON switch circuit, as applicable.
	EXTERNAL-DIRECT FUNCTION	To check the "external-direct" function when an external timing signal is used, apply a 1-kHz prf square wave to the EXT Timing connector on the rear panel. A GR Type 1340 Pulse Generator, or equivalent, is recommended. Adjust the amplitude of the signal to 10 V pk-pk. Set the timing switch to EXT DIR.		
17.	EXTERNAL DIRECT	Q108 base		Check C108, R120, and R121.

Parts Lists and Diagrams – Section 7

7.1 GENERAL

This section contains the replaceable-parts lists, schematics, and etched-circuit board layouts. The Federal manufacture's code numbers in the parts lists are identified in the "Federal Manufacturers Code" listing at the rear of the section. The section is arranged so that the parts listing, etched-circuit board layout and schematic diagram of a circuit board are all in one subsection.

Figures 7-1 and 7-2 identify the front-panel and rear-panel components. Refer to Figure 6-5 for the locations of other internally-mounted chassis components.

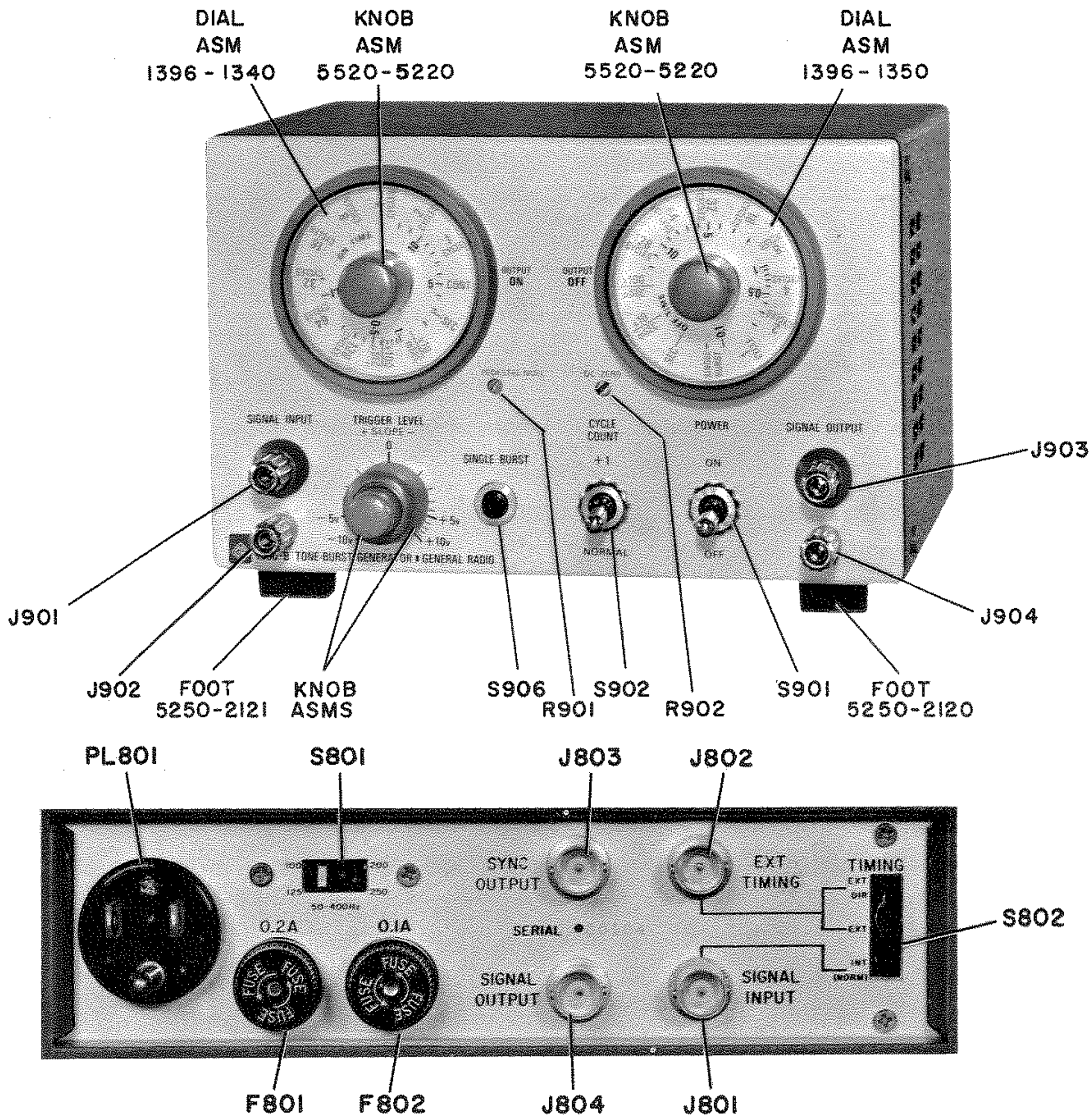


Figure 7-1. Front- and rear-panel components identification.

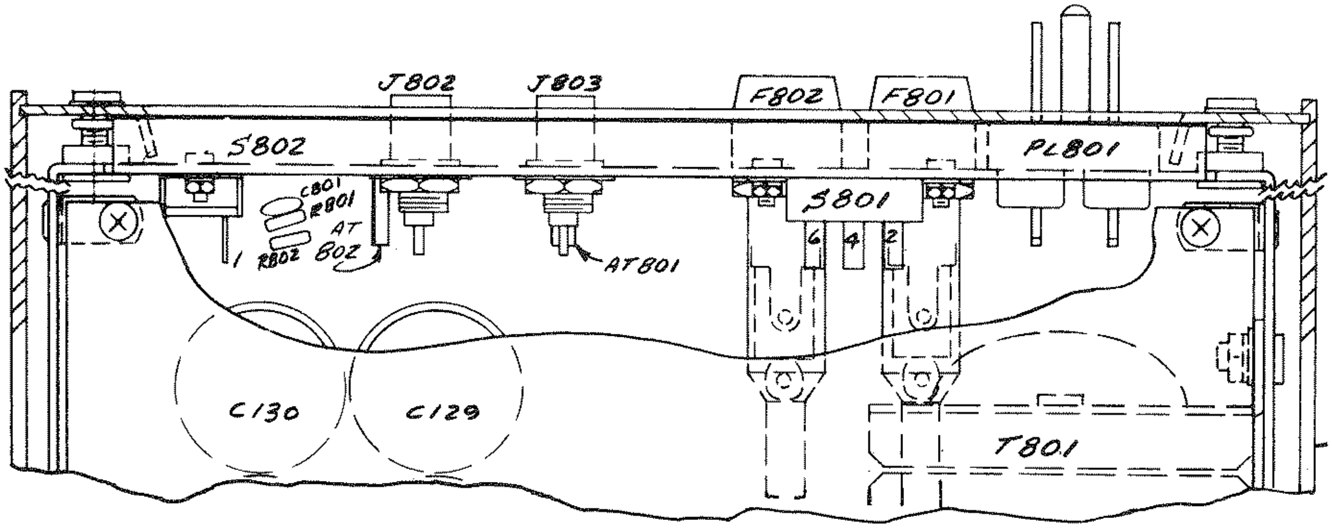


Figure 7-2. Top view of the rear panel showing the locations of panel components.

CHASSIS MECHANICAL REPLACEABLE PARTS

Description	GR Part No.	Fed. Mfg. Code	Mfg. Part No.	Fed. Stock No.
DIAL COMPLETE (OUTPUT ON)	1396-2300	24655	1396-2300	
Dial Asm.	1396-1340	24655	1396-1340	
Knob Asm.	5520-5220	24655	5520-5220	
DIAL COMPLETE (OUTPUT OFF)	1396-2310	24655	1396-2310	
Dial Asm.	1396-1350	24655	1396-1350	
Knob Asm.	5520-5220	24655	5520-5220	
CABINET-CONVERTIBLE BENCH	4181-1310	24655	4181-1310	
Foot, Black Phenolic	5250-2120	24655	5250-2120	
Foot, Black Phenolic	5250-2121	24655	5250-2121	
Foot, Black Neoprene, Durometer	5260-2060	24655	5260-2060	
POWER CABLE	4200-9622	24655	4200-9622	6150-968-0081
KNOB ASM. (TRIGGER LEVEL-outer knob)	5520-5132	24655	5520-5132	
KNOB ASM. (TRIGGER LEVEL-inner knob)	5520-5331	24655	5520-5331	
LAMP HOLDER, PAINTED	5600-1021	24655	5600-1021	
SCALER CIRCUIT ASM.	1396-2750	24655	1396-2750	
MAIN CIRCUIT ASM.	1396-2761	24655	1396-2761	
INSULATOR, BINDING POST 901, 903	1396-7130	24655	1396-7130	

CHASSIS ELECTRICAL REPLACEABLE PARTS

Ref. Desig.	Description		GR Part No.	Fed. Mfg. Code	Mfg. Part No.	Fed. Stock No.
CAPACITORS						
C801	Ceramic,	560 ρF ± 10% 500V	4404-1568	72982	831, 560 ρF ± 10%	
C901	Mica,	120 ρF ± 5% 500V	4640-0520	72136	CM15, 120 ρF ± 5%	
C902	Plastic,	.022 μF ± 2% 100V	4860-7858	84411	663 μW, 0.022 μF ± 2%	5910-051-6075
C903	Plastic,	2.2 μF ± 5% 50V	4860-9852	84411	663 μW, 2.2 μF ± 5%	
C904	Ceramic,	180 ρF ± 5% 500V	4404-1185	72982	831, 180 ρF ± 5%	5910-952-8403
C905	Ceramic,	.01 μF + 80 - 20% 50V	4401-3100	80131	CC61, 0.01 μF + 80 - 20%	5910-974-5697
C906	Mica,	120 ρF ± 5% 500V	4640-0520	72136	CM15, 120 ρF ± 5%	
C907	Plastic,	.022 μF ± 2% 100V	4860-7858	84411	663 μW, 0.022 μF ± 2%	5910-051-6075
C908	Plastic,	2.2 μF ± 5% 50V	4860-9852	84411	663 μW, 2.2 μF ± 5%	
FUSES						
F801	Slo-Blo	0.2 Amp	5330-0600	71400	MDL, 0.2 Amp.	
F802	Slo-Blo	0.1 Amp	5330-0400	71400	MDL, 0.1 Amp.	5920-356-2185
JACKS						
J801	Connector, BNC		4230-2300	81349	UG-1094/μ	
J802	Connector, BNC		4230-2300	81349	UG-1094/μ	
J803	Connector, BNC		4230-2300	81349	UG-1094/μ	
J804	Connector, BNC		4230-2300	81349	UG-1094/μ	
J901	Binding Post		0938-3000	24655	0938-3000	
J902	Binding Post		0938-3022	24655	0938-3022	
J903	Binding Post		0938-3000	24655	0938-3000	
J904	Binding Post		0938-3022	24655	0938-3022	
LAMPS						
P901	Chicago Miniature Lamp Works #327		5600-0313	71744	#327	
P902	Chicago Miniature Lamp Works #327		5600-0313	71744	#327	
PLUG						
PL801	Connector, Power Plug		4240-0600	24655	4240-0600	5935-816-0254
RESISTORS						
R801	Composition,	5.1KΩ ± 5% 1/4W	6099-2515	75042	BTS, 5.1KΩ ± 5%	5905-279-4623
R802	Composition,	15KΩ ± 5% 1/4W	6099-3155	75042	BTS, 15KΩ ± 5%	5905-681-8818
R901	Potentiometer,	5MΩ ± 20%	6010-2700	01121	JU, 5MΩ ± 20%	
R902	Potentiometer,	100Ω ± 10%	6010-0150	24655	6010-0150	
R903	Potentiometer,	5MΩ ± 20%	6020-1100	01121	JW, 5MΩ ± 20%	
R904	Potentiometer,	5MΩ ± 20%	6020-1100	01121	JW, 5MΩ ± 20%	
R905	Potentiometer,	200KΩ ± 10%	6010-4208	24655	6010-4208	
R906	Composition,	10KΩ ± 10% 1/4W	6099-3109	75042	BTS, 10KΩ ± 10%	
R907	Composition,	10KΩ ± 10% 1/4W	6099-3109	75042	BTS, 10KΩ ± 10%	
R908	Composition,	220Ω ± 10% 1/4W	6099-1229	75042	BTS, 220KΩ ± 10%	
R909	Composition,	1MΩ ± 10% 1/4W	6099-5109	75042	BTS, 1MΩ ± 10%	
R910	Composition,	10KΩ ± 10% 1/4W	6099-3109	75042	BTS, 10KΩ ± 10%	
R911	Composition,	10KΩ ± 10% 1/4W	6099-3109	75042	BTS, 10KΩ ± 10%	
SWITCHES						
S801	DPDT, non-shorting type, 0.5A, 125 Vdc		7910-0831	42190	4603	
S802	Toggle,		7910-1660	82389	13037	
S901	DPST, Toggle		7910-1300	04009	83053-SA	5930-909-3510
S902	DPDT, Toggle		7910-0800	04009	83052-SA	
S903	Rotary, Wafer		7890-5070	24655	7890-5070	
S904	Rotary, Wafer		7890-5070	24655	7890-5070	
S905	Rotary, Wafer		Part of 6049-4208			
S906	Pushbutton, single		7870-1518	82389	No. 983	
TRANSFORMER						
T801			0345-4024	24655	0345-4024	

MAIN CIRCUIT BOARD REPLACEABLE PARTS

Ref. Desig.	Description		GR Part No.	Fed. Mfg. Code	Mfg. Part No.	Fed. Stock No.
CAPACITORS						
C101	Ceramic,	3.6 ρF ± 5%	4400-0500	78488	GA, 3.6 ρF ± 5%	
C102	Ceramic,	10 ρF ± 10% 500V	4404-0108	72982	831, 10 ρF ± 10%	
C103	Ceramic,	10 ρF ± 10% 500V	4404-0108	72982	831, 10 ρF ± 10%	
C104	Ceramic,	47 ρF ± 10% 500V	4404-0478	72982	831, 47 ρF ± 10%	
C105	Ceramic,	.01 μF +80 -20% 50V	4401-3100	80131	CC61, 0.01μF +80 -20%	5910-974-5697
C106	Ceramic,	220ρF ± 10% 500V	4404-1228	72982	831, 220ρF	
C107	Ceramic,	20ρF ± 10% 500V	4404-0208	72982	831, 20ρF ± 10%	
C108	Ceramic,	100ρF ± 10% 500V	4404-1108	72982	831, 100ρF ± 10%	
C109	Ceramic,	39ρF ± 10% 500V	4404-0398	72982	831, 39ρF ± 10%	
C110	Ceramic,	39ρF ± 10% 500V	4404-0398	72982	831, 39ρF ± 10%	
C111	Ceramic,	.01μF +80 -20% 50V	4401-3100	80131	CC61, 0.01μF +80 -20%	5910-974-5697
C112	Ceramic,	20ρF ± 10% 500V	4404-0208	72982	831, 220ρF ± 10%	
C113	Ceramic,	47ρF ± 10% 500V	4404-0478	72982	831, 47ρF ± 10%	
C114	Ceramic,	47ρF ± 10% 500V	4404-0478	72982	831, 47ρF ± 10%	
C115	Ceramic,	.01μF +80 -20% 50V	4401-3100	80131	CC61, 0.01μF +80 -20%	5910-974-5697
C116	Ceramic,	47ρF ± 10% 500V	4404-0478	72982	831, 47ρF ± 10%	
C117	Ceramic,	47ρF ± 10% 500V	4404-0478	72982	831, 47ρF ± 10%	
C118	Ceramic,	.01μF +80 -20% 50V	4401-3100	80131	CC61, 0.01μF +80 -20%	5910-974-5697
C119	Ceramic,	47ρF ± 10% 500V	4404-0478	72982	831, 47ρF ± 10%	
C120	Ceramic,	20ρF ± 10% 500V	4404-0208	72982	831, 20ρF ± 10%	
C121	Ceramic,	27ρF ± 10% 500V	4404-0278	72982	831, 27ρF ± 10%	
C122	Ceramic,	47ρF ± 10% 500V	4404-0478	72982	831, 47ρF ± 10%	
C123	Ceramic,	.01μF +80 -20% 50V	4401-3100	80131	CC61, 0.01μF +80 -20%	5910-974-5697
C124	Ceramic,	47ρF ± 10% 500V	4404-0478	72982	831, 47ρF ± 10%	
C125	Ceramic,	20ρF ± 10% 500V	4404-0208	72982	831, 20ρF ± 10%	
C126	Ceramic,	470ρF ± 10% 500V	4404-1478	72982	831, 470ρF ± 10%	
C127	Electrolytic,	5μF 50V	4450-3900	37942	2040595S9C10X3	5910-448-5527
C128	Ceramic,	220ρF ± 10% 500V	4404-1228	72982	831, 220ρF ± 10%	
C129	Electrolytic,	600μF 35V	4450-2400	37942	2021149S4C10X1	5910-822-2691
C130	Electrolytic,	600μF 35V	4450-2400	37942	2021149S4C10X1	5910-822-2691
C131	Electrolytic,	800μF 25V	4450-5621	37942	TT, 400/400μF	
C132	Electrolytic,	800μF 25V	4450-5621	37942	TT, 400/400μF	
C133	Ceramic,	47ρF + 10% 500V	4400-0471	78488	GA, 47ρF + 10%	
C134	Ceramic,	.01μF +80 -20% 50V	4401-3100	80131	CC61, 0.01μF +80 -20%	5910-974-5697
C135	Trimmer,	1.5-7ρF 350V	4910-1110	72982	557-051, U2P0, 1.5 to 7ρF	
C136	Trimmer,	8-50ρF 350V	4910-1170	72982	557-051, 8-50ρF	5910-083-6446
C137	Ceramic,	.01μF +80 -20% 50V	4401-3100	80131	CC61, 0.01μF +80 -20%	5910-974-5697
C138	Ceramic,	33ρF ± 5% 500V	4404-0335	72982	831, 33ρF ± 5%	
C139	Ceramic,	100ρF ± 10% 500V	4404-1108	72982	831, 100ρF + 10%	
C140	Electrolytic,	1μF ± 20% 35V	4450-4300	56289	150D105X0035A2	5910-726-5003
C141	Electrolytic,	1μF ± 20% 35V	4450-4300	56289	150D105X0035A2	5910-726-5003
C142	Ceramic,	10ρF ± 10% 500V	4404-0108	72982	831, 10ρF ± 10%	
C143	Ceramic,	.01μF +80 -20% 50V	4401-3100	80131	CC61, 0.01μF +80 -20%	5910-974-5697
C144	Ceramic	2.4ρF ± 5%	4400-0250	78488	GA, 2.4ρF	
DIODES						
CR101	Type 1N3604		6082-1001	24446	1N3604	5960-995-2199
CR102	Type 1N3604		6082-1001	24446	1N3604	5960-995-2199
CR103	Type 1N3604		6082-1001	24446	1N3604	5960-995-2199
CR104	Type 1N3604		6082-1001	24446	1N3604	5960-995-2199
CR105	Type 1N3604		6082-1001	24446	1N3604	5960-995-2199
CR106	Type 1N3604		6082-1001	24446	1N3604	5960-995-2199
CR107	Type 1N3604		6082-1001	24446	1N3604	5960-995-2199
CR108	Type 1N3604		6082-1001	24446	1N3604	5960-995-2199
CR109	Type 1N3604		6082-1001	24446	1N3604	5960-995-2199

MAIN CIRCUIT BOARD REPLACEABLE PARTS (CONT'D)

Ref. Desig.	Description	GR Part No.	Fed. Mfg. Code	Mfg. Part No.	Fed. Stock No.
DIODES Cont.					
CR110	Type 1N3604	6082-1001	24446	1N3604	5960-995-2199
CR111	Type 1N4003	6081-1001	79089	1N3253	5961-814-4251
CR112	Type 1N4003	6081-1001	79089	1N3253	5961-814-4251
CR113	Type 1N4003	6081-1001	79089	1N3253	5961-814-4251
CR114	Type 1N4003	6081-1001	79089	1N3253	5961-814-4251
CR115	Type 1N785A	6083-1012	07910	1N758-A	5961-814-4251
INDUCTOR					
L101	Choke, molded 0.15μH ± 10%	4300-0101	94800	1537, 0.15μH ± 10%	
RESISTORS					
R103	Composition, 220Ω ± 10% 1/4W	6099-1229	75042	BTS, 220Ω ± 10%	
R104	Composition, 220Ω ± 10% 1/4W	6099-1229	75042	BTS, 220Ω ± 10%	
R105	Composition, 2.2KΩ ± 10% 1/4W	6099-2229	75042	BTS, 2.2KΩ ± 10%	
R106	Composition, 2.2KΩ ± 10% 1/4W	6099-2229	75042	BTS, 2.2KΩ ± 10%	
R107	Composition, 3.3KΩ ± 5% 1/2W	6100-2335	01121	RC20GF332J	5905-279-3506
R108	Composition, 10KΩ ± 10% 1/4W	6099-3109	75042	BTS, 10KΩ ± 10%	
R109	Composition, 6.8KΩ ± 5% 1/4W	6099-2685	75042	BTS, 6.8KΩ ± 5%	5905-686-9997
R110	Composition, 3.3KΩ ± 5% 1/4W	6099-2335	75042	BTS, 3.3KΩ ± 5%	5905-279-3506
R111	Composition, 7.5KΩ ± 5% 1/4W	6099-2755	75042	BTS, 7.5KΩ ± 5%	
R113	Composition, 10KΩ ± 10% 1/4W	6099-3109	75042	BTS, 10KΩ ± 10%	
R114	Composition, 10KΩ ± 10% 1/4W	6099-3109	75042	BTS, 10KΩ ± 10%	
R115	Composition, 2.2KΩ ± 10% 1/4W	6099-2229	75042	BTS, 2.2KΩ ± 10%	
R116	Composition, 3.9KΩ ± 5% 1/4W	6099-3395	75042	BTS, 3.9KΩ ± 5%	5905-686-3358
R117	Composition, 470Ω ± 10% 1/4W	6099-1479	75042	BTS, 470Ω ± 10%	
R118	Composition, 4.7KΩ ± 10% 1/4W	6099-2479	75042	BTS, 4.7KΩ ± 10%	
R119	Composition, 20KΩ ± 5% 1/4W	6099-3205	75042	BTS, 20KΩ ± 5%	5905-686-3368
R120	Composition, 2.2KΩ ± 10% 1/4W	6099-2229	75042	BTS, 2.2KΩ ± 10%	
R121	Composition, 270KΩ ± 5% 1/4W	6099-4275	75042	BTS, 270KΩ ± 5%	
R122	Composition, 270KΩ ± 5% 1/4W	6099-4275	75042	BTS, 270KΩ ± 5%	
R123	Composition, 4.3KΩ ± 5% 1/4W	6099-2435	75042	BTS, 4.3KΩ ± 5%	
R124	Composition, 4.3KΩ ± 5% 1/4W	6099-2435	75042	BTS, 4.3KΩ ± 5%	
R125	Composition, 300Ω ± 5% 1/4W	6099-1305	75042	BTS, 300Ω ± 5%	5905-279-5481
R126	Composition, 300Ω ± 5% 1/4W	6099-1305	75042	BTS, 300Ω ± 5%	5905-279-5481
R127	Composition, 330Ω ± 5% 1/4W	6099-1335	75042	BTS, 330Ω ± 5%	5905-686-3369
R128	Composition, 330Ω ± 5% 1/4W	6099-1335	75042	BTS, 330Ω ± 5%	5905-686-3369
R129	Composition, 1.2KΩ ± 5% 1/4W	6099-2125	75042	BTS, 1.2KΩ ± 5%	
R130	Composition, 470Ω ± 10% 1/4W	6099-1479	75042	BTS, 470Ω ± 10%	
R131	Composition, 4.7KΩ ± 10% 1/4W	6099-2479	75042	BTS, 4.7KΩ ± 10%	
R132	Composition, 20KΩ ± 5% 1/4W	6099-3205	75042	BTS, 20KΩ ± 5%	5905-686-3368
R133	Composition, 39KΩ ± 5% 1/4W	6099-3395	75042	BTS, 39KΩ ± 5%	5905-686-3358
R134	Composition, 39KΩ ± 5% 1/4W	6099-3395	75042	BTS, 39KΩ ± 5%	5905-686-3358
R135	Composition, 2.2KΩ ± 10% 1/4W	6099-2229	75042	BTS, 2.2KΩ ± 10%	
R136	Composition, 22KΩ ± 10% 1/4W	6099-3229	75042	BTS, 22KΩ ± 10%	
R137	Composition, 4.7KΩ ± 10% 1/4W	6099-2479	75042	BTS, 4.7KΩ ± 10%	
R138	Composition, 4.7KΩ ± 10% 1/4W	6099-2479	75042	BTS, 4.7KΩ ± 10%	
R139	Composition, 270KΩ ± 5% 1/4W	6099-4275	75042	BTS, 270KΩ ± 5%	
R140	Composition, 910Ω ± 5% 1/4W	6099-1915	75042	BTS, 910Ω ± 5%	
R141	Composition, 620Ω ± 5% 1/4W	6099-1625	75042	BTS, 620Ω ± 5%	5905-801-6998
R142	Composition, 620Ω ± 5% 1/4W	6099-1625	75042	BTS, 620Ω ± 5%	5905-801-6998
R143	Composition, 4.7KΩ ± 10% 1/4W	6099-2479	75042	BTS, 4.7KΩ ± 10%	

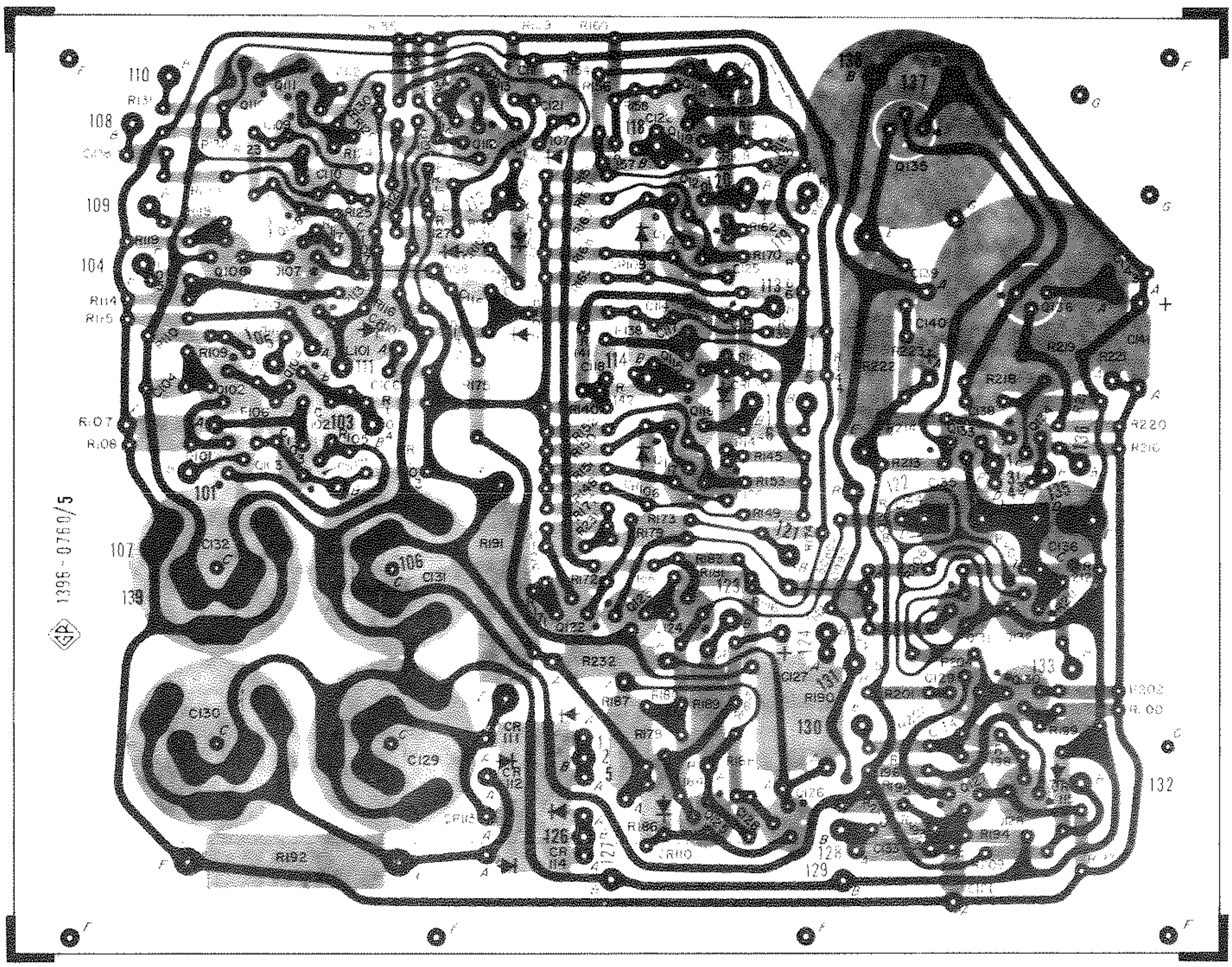
MAIN CIRCUIT BOARD REPLACEABLE PARTS (CONT'D)

Ref. Desig.	Description		GR Part No.	Fed. Mfg. Code	Mfg. Part No.	Fed. Stock No.
RESISTORS Cont.						
R144	Composition,	270KΩ ± 5% 1/4W	6099-4275	75042	BTS, 270KΩ ± 5%	
R145	Composition,	10KΩ ± 10% 1/4W	6099-3109	75042	BTS, 10KΩ ± 10%	
R147	Composition,	33KΩ ± 5% 1/4W	6099-3335	75042	BTS, 33KΩ ± 5%	
R148	Composition,	27KΩ ± 10% 1/4W	6099-3279	75042	BTS, 27KΩ ± 10%	
R149	Composition,	470K ± 10% 1/4W	6099-4479	75042	BTS, 470K ± 10%	
R150	Composition,	1.8MΩ ± 10% 1/4W	6099-5189	75042	BTS, 1.8MΩ ± 10%	
R151	Composition,	39KΩ ± 10% 1/4W	6099-3399	75042	BTS, 39KΩ ± 10%	
R152	Composition,	100KΩ ± 5% 1/4W	6099-4105	75042	BTS, 100KΩ ± 5%	5905-686-3129
R153	Composition,	16KΩ ± 5% 1/4W	6099-3165	75042	BTS, 16KΩ ± 5%	
R154	Composition,	4.7KΩ ± 10% 1/4W	6099-2479	75042	BTS, 4.7KΩ ± 10%	
R155	Composition,	910Ω ± 5% 1/4W	6099-1915	75042	BTS, 910Ω ± 5%	
R156	Composition,	620Ω ± 5% 1/4W	6099-1625	75042	BTS, 620Ω ± 5%	5905-801-6998
R157	Composition,	620Ω ± 5% 1/4W	6099-1625	75042	BTS, 620Ω ± 5%	5905-801-6998
R158	Composition,	4.7KΩ ± 10% 1/4W	6099-2479	75042	BTS, 4.7KΩ ± 10%	
R159	Composition,	4.7KΩ ± 10% 1/4W	6099-2479	75042	BTS, 4.7KΩ ± 10%	
R160	Composition,	270KΩ ± 5% 1/4W	6099-4275	75042	BTS, 270KΩ ± 5%	
R161	Composition,	270KΩ ± 5% 1/4W	6099-4275	75042	BTS, 270KΩ ± 5%	
R162	Composition,	10KΩ ± 10% 1/4W	6099-3109	75042	BTS, 10KΩ ± 10%	
R164	Composition,	33KΩ ± 5% 1/4W	6099-3335	75042	BTS, 33KΩ ± 5%	
R165	Composition,	27KΩ ± 10% 1/4W	6099-3279	75042	BTS, 27KΩ ± 10%	
R166	Composition,	470KΩ ± 10% 1/4W	6099-4479	75042	BTS, 470KΩ ± 10%	
R167	Composition,	1.8MΩ ± 10% 1/4W	6099-5189	75042	BTS, 1.8MΩ ± 10%	
R168	Composition,	39KΩ ± 10% 1/4W	6099-3399	75042	BTS, 39KΩ ± 10%	
R169	Composition,	100KΩ ± 5% 1/4W	6099-4105	75042	BTS, 100KΩ ± 5%	5905-
R170	Composition,	16KΩ ± 5% 1/4W	6099-3165	75042	BTS, 16KΩ + 5%	
R171	Composition,	330Ω ± 5% 1/4W	6099-1335	75042	BTS, 330Ω ± 5%	
R172	Composition,	8.2KΩ ± 5% 1/4W	6099-2825	75042	BTS, 8.2KΩ ± 5%	
R173	Composition,	1KΩ ± 5% 1/4W	6099-2105	75042	BTS, 1KΩ ± 5%	
R174	Composition,	3KΩ ± 5% 1/4W	6099-2305	75042	BTS, 3KΩ ± 5%	
R175	Film,	2.05KΩ ± 1% 1/8W	6250-1205	75042	CEA, 2.05KΩ ± 1%	
R176	Film,	4.02KΩ ± 1% 1/8W	6250-1402	75042	CEA, 4.02KΩ ± 1%	5905-702-7231
R177	Composition,	300Ω ± 5% 1/4W	6099-1305	75042	BTS, 300Ω ± 5%	5905-279-5481
R178	Composition,	300Ω ± 5% 1/4W	6099-1305	75042	BTS, 300Ω ± 5%	5905-279-5481
R179	Film,	1.47KΩ ± 1% 1/8W	6250-1147	75042	CEA, 1.47KΩ ± 1%	5905-804-9710
R180	Composition,	1.1KΩ ± 5% 1/4W	6099-2115	75042	BTS, 1.1KΩ ± 5%	
R181	Film,	825Ω ± 1% 1/8W	6150-0825	75042	CEA, 825Ω ± 1%	5905-702-4172
R182	Composition,	2KΩ ± 5% 1/4W	6099-2205	75042	BTS, 2KΩ ± 5%	5905-279-4629
R183	Composition,	3.9KΩ ± 5% 1/4W	6099-2395	75042	BTS, 3.9KΩ ±5%	
R184	Composition,	3KΩ ± 5% 1/4 W	6099-2305	75042	BTS, 3KΩ	5905-682-4097
R185	Composition,	6.8KΩ ± 10% 1/4 W	6099-2689	75042	BTS, 6.8KΩ ± 10%	
R186	Composition,	36Ω ± 5% 1/4 W	6099-0365	75042	BTS, 36Ω ± 5%	
R187	Composition,	2KΩ ± 5% 1 W	6110-2205	01121	GB, 2KΩ ± 5%	
R188	Composition,	33KΩ + 10% 1/4W	6099-3339	75042	BTS, 33KΩ ± 10%	
R189	Composition,	430Ω ± 5% 1W	6110-1435	01121	GB, 430Ω ± 5%	
R190	Composition,	430Ω ± 5% 1W	6110-1435	01121	GB, 430Ω ± 5%	
R191	Power,	56Ω ± 5% 5W	6660-0565	80183	246E, 56Ω ± 5%	
R192	Power,	56Ω ± 5% 5W	6660-0565	80183	246E, 56Ω ± 5%	
R193	Composition,	24KΩ ± 5% 1/4W	6099-3245	75042	BTS, 24KΩ ± 5%	
R194	Composition,	27KΩ ± 5% 1/4W	6099-3275	75042	BTS, 27KΩ ± 5%	5905-683-3838
R195	Composition,	4.7KΩ ±10% 1/4W	6099-2479	75042	BTS, 4.7KΩ ± 10%	
R196	Composition,	1KΩ ± 10% 1/4 W	6099-2109	75042	BTS, 1KΩ ± 10%	
R197	Composition,	4.7KΩ ± 10% 1/4W	6099-2479	75042	BTS, 4.7KΩ ± 10%	
R198	Composition,	3.9KΩ ± 5% 1/4W	6099-2395	75042	BTS, 3.9KΩ ± 5%	

MAIN CIRCUIT BOARD REPLACEABLE PARTS (CONT'D)

Ref. Design	Description		GR Part No.	Fed. Mfg. Code	Mfg. Part No.	Fed. Stock No.
RESISTORS Cont.						
R199	Composition,	8.2KΩ ± 5% 1/4W	6099-2825	75042	BTS, 8.2KΩ ± 5%	
R200	Composition,	12KΩ ± 5% 1/4W	6099-3125	75042	BTS, 12KΩ ± 5%	
R201	Composition,	750Ω ± 5% 1/4W	6099-1755	75042	BTS, 750Ω ± 5%	
R202	Composition,	1.1KΩ ± 5% 1/4W	6099-2115	75042	BTS, 1.1KΩ ± 5%	
R203	Composition,	100Ω ± 5% 1/4W	6099-1105	75042	BTS, 100Ω ± 5%	
R204	Composition,	2KΩ ± 5% 1/4W	6099-2205	75042	BTS, 2KΩ ± 5%	5905-279-4629
R205	Composition,	4.3KΩ ± 5% 1/4W	6099-2435	75042	BTS, 4.3KΩ ± 5%	
R206	Composition,	13KΩ ± 5% 1/4W	6099-3135	75042	BTS, 13KΩ ± 5%	
R207	Composition,	1KΩ ± 5% 1/4W	6099-2105	75042	BTS, 1KΩ ± 5%	5905-681-6462
R208	Composition,	39KΩ ± 5% 1/4W	6099-3395	75042	BTS, 39KΩ ± 5%	5905-686-3358
R209	Composition,	15KΩ ± 10% 1/4W	6099-3159	75042	BTS, 15KΩ ± 10%	
R210	Composition,	2MΩ ± 5% 1/4W	6099-5205	75042	BTS, 2MΩ ± 5%	
R211	Composition,	68KΩ ± 10% 1/4W	6099-3689	75042	BTS, 68KΩ ± 10%	
R212	Composition,	10KΩ ± 5% 1/4W	6099-3105	75042	BTS, 10KΩ ± 5%	5905-683-2238
R213	Composition,	2.2KΩ ± 5% 1/4W	6099-2225	75042	BTS, 2.2KΩ ± 5%	5905-723-5251
R214	Composition,	1KΩ ± 10% 1/4W	6099-2109	75042	BTS, 1KΩ ± 10%	
R216	Composition,	3.6KΩ ± 5% 1/4W	6099-2365	75042	BTS, 3.6KΩ ± 5%	5905-577-0627
R217	Film	1KΩ ± 1% 1/8W	6250-1100	75042	CEA, 1KΩ ± 1%	5905-581-6915
R218	Film,	1.54KΩ ± 1% 1/8W	6250-1154	75042	CEA, 1.54KΩ ± 1%	5905-702-1144
R219	Composition,	1.1KΩ ± 5% 1/4W	6099-2115	75042	BTS, 1.1KΩ ± 5%	
R220	Composition,	680Ω ± 5% 1/4W	6099-1685	75042	BTS, 680Ω ± 5%	
R221	Composition,	160Ω ± 5% 1/2W	6100-1165	01121	RC20GF161J	5905-256-0415
R222	Power,	100Ω ± 5% 5W	6660-1105	80183	246E, 100Ω ± 5%	
R223	Composition,	51Ω ± 5% 1/4W	6099-0515	75042	BTS, 51Ω ± 5%	
R231	Composition,	1KΩ ± 10% 1/4W	6099-2109	75042	BTS, 1KΩ ± 10%	
R232	Composition,	2KΩ ± 5% 1W	6110-2205	01121	GB, 2KΩ ± 5%	
TRANSISTORS						
Q101	Type	2N4124	8210-1154	93916	2N4124	
Q102	Type	2N4124	8210-1154	93916	2N4124	
Q103	Type	2N3646	8210-1119	07263	2N3646	
Q104	Type	2N3646	8210-1119	07263	2N3646	
Q105	Type	2N3646	8210-1119	07263	2N3646	
Q106	Type	2N4258	8210-1136	93916	2N4258	
Q107	Type	2N4258	8210-1136	93916	2N4258	
Q108	Type	2N4258	8210-1136	93916	2N4258	
Q109	Type	2N4258	8210-1136	93916	2N4258	
Q110	Type	2N4258	8210-1136	93916	2N4258	
Q111	Type	2N4258	8210-1136	93916	2N4258	
Q112	Type	2N3640	8210-1136	93916	2N3640	
Q113	Type	2N3640	8210-1129	93916	2N3640	
Q114	Type	2N3646	8210-1119	07263	2N3646	
Q115	Type	2N3646	8210-1119	07263	2N3646	
Q116	Type	2N3391A	8210-1092	24454	2N3391A	
Q117	Type	2N4250	8210-1135	93916	2N4250	
Q118	Type	2N3646	8210-1119	07263	2N3646	
Q119	Type	2N3646	8210-1119	07263	2N3646	
Q120	Type	2N3391A	8210-1092	24454	2N3391A	
Q121	Type	2N4250	8210-1135	93916	2N4250	
Q122	Type	2N3905	8210-1114	04713	2N3905	
Q123	Type	2N4124	8210-1154	93916	2N4124	
Q124	Type	2N4124	8210-1154	93916	2N4124	
Q125	Type	2N4250	8210-1135	93916	2N4250	
Q126	Type	2N4250	8210-1135	93916	2N4250	
Q127	Type	2N4124	8210-1154	93916	2N4124	
Q128	Type	2N4124	8210-1154	93916	2N4124	

Ref. Desig.	Description		GR Part No.	Fed. Mfg. Code	Mfg. Part No.	Fed. Stock No.
TRANSISTORS Cont.						
Q129	Type,	2N3905	8210-1114	04713	2N3905	
Q130	Type,	2N708	8210-3089	24454	2N708	
Q131	Type,	2N4275	8210-1126	23342	2N4275	
Q132	Type,	2N4275	8210-1126	23342	2N4275	
Q133	Type,	2N3414	8210-1047	24446	2N3414	5961-989-2749
Q134	Type,	2N3414	8210-1047	24446	2N3414	5961-989-2749
Q135	Type,	2N2904	8210-1074	93916	2N2904	
Q136	Type,	2N2102	8210-1137	93916	2112102	



NOTE

The number shown on the foil side of the board is not the part number for the complete assembly. This assembly number is given in the caption.

The dot on the foil at the transistor socket indicates the collector lead.

Figure 7-3. Etched-circuit board assembly, main circuit and power supply (P/N 1396-2750).

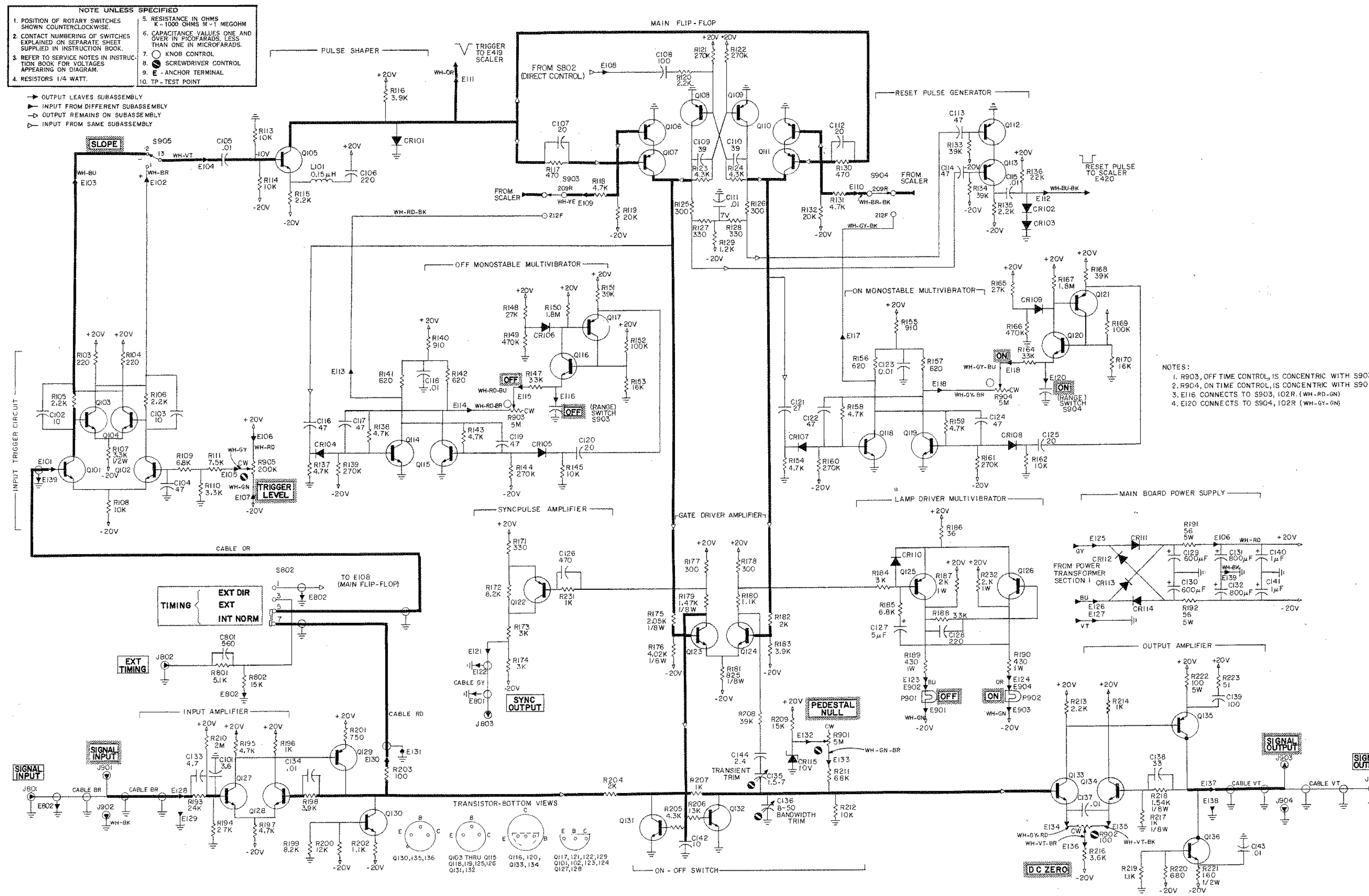


Figure 7-4. Main circuit and power supply schematic diagram.

SCALER CIRCUIT BOARD REPLACEABLE PARTS

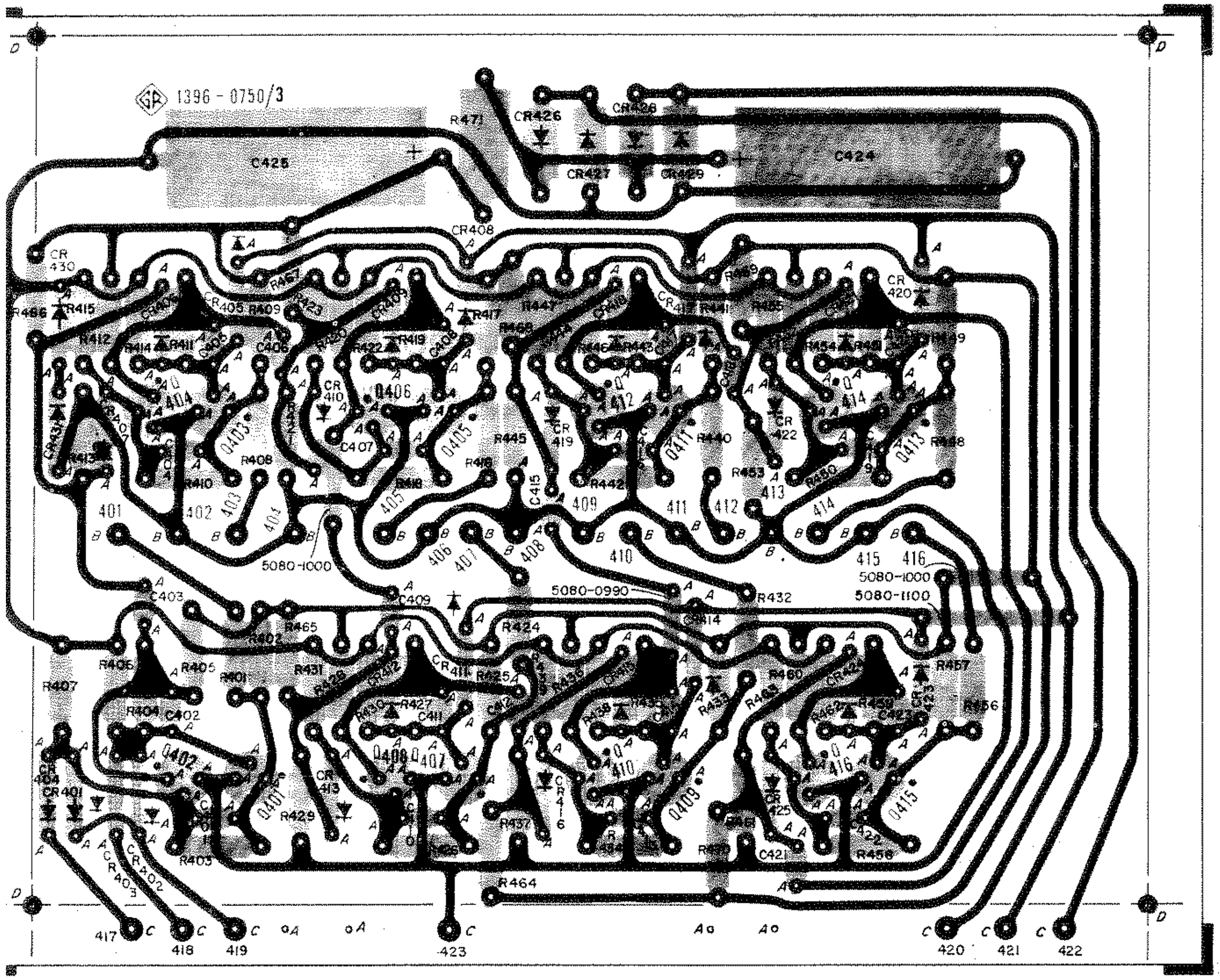
Ref. Desig.	Description		GR Part No.	Fed. Mfg. Code	Mfg. Part No.
CAPACITORS					
C401	Ceramic,	47 pF ± 10% 500V	4404-0478	72982	831, 47 pF ± 10%
C402	Ceramic,	47 pF ± 10% 500V	4404-0478	72982	831, 47 pF ± 10%
C403	Ceramic,	15 pF (NPO) + 10% 500V	4410-0158	80131	801, 15 pF ± 10%
C404	Ceramic,	47 pF ± 10% 500V	4404-0478	72982	831, 47 pF ± 10%
C405	Ceramic,	47 pF ± 10% 500V	4404-0478	72982	831, 47 pF ± 10%
C406	Ceramic,	22 pF ± 10% 500V	4404-0228	72982	831, 22 pF ± 10%
C407	Ceramic,	47 pF ± 10% 500V	4404-0478	72982	831, 47 pF ± 10%
C408	Ceramic,	47 pF ± 10% 500V	4404-0478	72982	831, 47 pF ± 10%
C409	Ceramic,	22 pF ± 10% 500V	4404-0228	72982	831, 22 pF ± 10%
C410	Ceramic,	47 pF ± 10% 500V	4404-0478	72982	831, 47 pF ± 10%
C411	Ceramic,	47 pF ± 10% 500V	4404-0478	72982	831, 47 pF ± 10%
C412	Ceramic,	22 pF ± 10% 500V	4404-0228	72982	831, 22 pF ± 10%
C413	Ceramic,	47 pF ± 10% 500V	4404-0478	72982	831, 47 pF ± 10%
C414	Ceramic,	47 pF ± 10% 500V	4404-0478	72982	831, 47 pF ± 10%
C415	Ceramic,	22 pF ± 10% 500V	4404-0228	72982	831, 22 pF ± 10%
C416	Ceramic,	47 pF ± 10% 500V	4404-0478	72982	831, 47 pF ± 10%
C417	Ceramic,	47 pF ± 10% 500V	4404-0478	72982	831, 47 pF ± 10%
C418	Ceramic,	22 pF ± 10% 500V	4404-0228	72982	831, 22 pF ± 10%
C419	Ceramic,	47 pF ± 10% 500V	4404-0478	72982	831, 47 pF ± 10%
C420	Ceramic,	47 pF ± 10% 500V	4404-0478	72982	831, 47 pF ± 10%
C421	Ceramic,	22 pF ± 10% 500V	4404-0228	72982	831, 22 pF ± 10%
C422	Ceramic,	47 pF ± 10% 500V	4404-0478	72982	831, 47 pF ± 10%
C423	Ceramic,	47 pF ± 10% 500V	4404-0478	72982	831, 47 pF ± 10%
C424	Electrolytic	500 µF ± 150 - 10% 20V	4450-6020	37942	TT, 500 µF ± 150 - 10%
C425	Electrolytic,	680 µF ± 150 - 10% 15V	4450-6015	37942	TT, 680 µF ± 150 - 10%
DIODES					
CR401	Type	1N4009	6082-1012	24446	1N4009
CR402	Type	1N4009	6082-1012	24446	1N4009
CR403	Type	1N4009	6082-1012	24446	1N4009
CR404	Type	1N4009	6082-1012	24446	1N4009
CR405	Type	1N4009	6082-1012	24446	1N4009
CR406	Type	1N4009	6082-1012	24446	1N4009
CR407	Type	1N4009	6082-1012	24446	1N4009
CR408	Type	1N4009	6082-1012	24446	1N4009
CR409	Type	1N4009	6082-1012	24446	1N4009
CR410	Type	1N4009	6082-1012	24446	1N4009
CR411	Type	1N4009	6082-1012	24446	1N4009
CR412	Type	1N4009	6082-1012	24446	1N4009
CR413	Type	1N4009	6082-1012	24446	1N4009
CR414	Type	1N4009	6082-1012	24446	1N4009
CR415	Type	1N4009	6082-1012	24446	1N4009
CR416	Type	1N4009	6082-1012	24446	1N4009
CR417	Type	1N4009	6082-1012	24446	1N4009
CR418	Type	1N4009	6082-1012	24446	1N4009
CR419	Type	1N4009	6082-1012	24446	1N4009
CR420	Type	1N4009	6082-1012	24446	1N4009

SCALER CIRCUIT BOARD REPLACEABLE PARTS (CONT'D)

Ref. Desig.	Description		GR Part No.	Fed. Mfg. Code	Mfg. Part No.	Fed. Stock No.
DIODES Cont.						
CR421	Type	1N4009	6082-1012	24446	1N4009	
CR422	Type	1N4009	6082-1012	24446	1N4009	
CR423	Type	1N4009	6082-1012	24446	1N4009	
CR424	Type	1N4009	6082-1012	24446	1N4009	
CR425	Type	1N4009	6082-1012	24446	1N4009	
CR426	Type	1N3253	6081-1001	79089	1N3253	5961-814-4251
CR427	Type	1N3253	6081-1001	79089	1N3253	5961-814-4251
CR428	Type	1N3253	6081-1001	79089	1N3253	5961-814-4251
CR429	Type	1N3253	6081-1001	79089	1N3253	5961-814-4251
CR430	Type	1N3253	6081-1001	79089	1N3253	5961-814-4251
CR431	Type	1N3253	6081-1001	79089	1N3253	5961-814-4251
RESISTORS						
R401	Composition,	160Ω ± 5% 1/2W	6100-1165	01121	RC20GF161J	5905-256-0415
R402	Composition,	620Ω ± 5% 1/2W	6100-1625	01121	RC20GF621J	5905-279-1761
R403	Composition,	4.7KΩ ± 5% 1/2W	6100-2475	01121	RC20GF472J	5905-279-3504
R404	Composition,	4.7KΩ ± 5% 1/2W	6100-2475	01121	RC20GF472J	5905-279-3504
R405	Composition,	620Ω ± 5% 1/2W	6100-1625	01121	RC20GF621J	5905-279-1761
R406	Composition,	20KΩ ± 5% 1/2W	6100-3205	01121	RC20GF203J	5905-192-0649
R407	Composition,	20KΩ ± 5% 1/2W	6100-3205	01121	RC20GF203J	5905-192-0649
R408	Composition,	160Ω ± 5% 1/2W	6100-1165	01121	RC20GF161J	5905-256-0415
R409	Composition,	620Ω ± 5% 1/2W	6100-1625	01121	RC20GF621J	5905-279-1761
R410	Composition,	4.7KΩ ± 5% 1/2W	6100-2475	01121	RC20GF472J	5905-279-3504
R411	Composition,	4.7KΩ ± 5% 1/2W	6100-2475	01121	RC20GF472J	5905-279-3504
R412	Composition,	620Ω ± 5% 1/2W	6100-1625	01121	RC20GF621J	5905-279-1761
R413	Composition,	2KΩ ± 5% 1/2W	6100-2205	01121	RC20GF202J	5905-190-8887
R414	Composition,	20KΩ ± 5% 1/2W	6100-3205	01121	RC20GF203J	5905-192-0649
R415	Composition,	20KΩ ± 5% 1/2W	6100-3205	01121	RC20GF203J	5905-192-0649
R416	Composition,	160Ω ± 5% 1/2W	6100-1165	01121	RC20GF161J	5905-256-0415
R417	Composition,	620Ω ± 5% 1/2W	6100-1625	01121	RC20GF621J	5905-279-1761
R418	Composition,	4.7KΩ ± 5% 1/2W	6100-2475	01121	RC20GF472J	5905-279-3504
R419	Composition,	4.7KΩ ± 5% 1/2W	6100-2475	01121	RC20GF472J	5905-279-3504
R420	Composition,	620Ω ± 5% 1/2W	6100-1625	01121	RC20GF621J	5905-279-1761
R421	Composition,	4.7KΩ ± 5% 1/2W	6100-2475	01121	RC20GF472J	5905-279-3504
R422	Composition,	20KΩ ± 5% 1/2W	6100-3205	01121	RC20GF203J	5905-192-0649
R423	Composition,	20KΩ ± 5% 1/2W	6100-3205	01121	RC20GF203J	5905-192-0649
R424	Composition,	160Ω ± 5% 1/2W	6100-1165	01121	RC20GF161J	5905-256-0415
R425	Composition,	620Ω ± 5% 1/2W	6100-1625	01121	RC20GF621J	5905-279-1761
R426	Composition,	4.7KΩ ± 5% 1/2W	6100-2475	01121	RC20GF472J	5905-279-3504
R427	Composition,	4.7KΩ ± 5% 1/2W	6100-2475	01121	RC20GF472J	5905-279-3504
R428	Composition,	620Ω ± 5% 1/2W	6100-1625	01121	RC20GF621J	5905-279-1761
R429	Composition,	4.7KΩ ± 5% 1/2W	6100-2475	01121	RC20GF472J	5905-279-3504
R430	Composition,	20KΩ ± 5% 1/2W	6100-3205	01121	RC20GF203J	5905-192-0649
R431	Composition,	20KΩ ± 5% 1/2W	6100-3205	01121	RC20GF203J	5905-192-0649
R432	Composition,	160Ω ± 5% 1/2W	6100-1165	01121	RC20GF161J	5905-256-0415
R433	Composition,	620Ω ± 5% 1/2W	6100-1625	01121	RC20GF621J	5905-279-1761
R434	Composition,	4.7KΩ ± 5% 1/2W	6100-2475	01121	RC20GF472J	5905-279-3504
R435	Composition,	4.7KΩ ± 5% 1/2W	6100-2475	01121	RC20GF472J	5905-279-3504
R436	Composition,	620Ω ± 5% 1/2W	6100-1625	01121	RC20GF621J	5905-279-1761
R437	Composition,	4.7KΩ ± 5% 1/2W	6100-2475	01121	RC20GF472J	5905-279-3504
R438	Composition,	20KΩ ± 5% 1/2W	6100-3205	01121	RC20GF203J	5905-192-0649
R439	Composition,	20KΩ ± 5% 1/2W	6100-3205	01121	RC20GF203J	5905-192-0649
R440	Composition,	160Ω ± 5% 1/2W	6100-1165	01121	RC20GF161J	5905-256-0415
R441	Composition,	620Ω ± 5% 1/2W	6100-1625	01121	RC20GF621J	5905-279-1761
R442	Composition,	4.7KΩ ± 5% 1/2W	6100-2475	01121	RC20GF472J	5905-279-3504
R443	Composition,	4.7KΩ ± 5% 1/2W	6100-2475	01121	RC20GF472J	5905-279-3504

SCALER CIRCUIT BOARD REPLACEABLE PARTS (CONT'D)

Ref. Desig.	Description		GR Part No.	Fed. Mfg. Code	Mfg. Part No.	Fed. Stock No.
RESISTORS Cont.						
R444	Composition,	620Ω ± 5% 1/2W	6100-1625	01121	RC20GF621J	5905-279-1761
R445	Composition,	4.7KΩ ± 5% 1/2W	6100-2475	01121	RC20GF472J	5905-279-3504
R446	Composition,	20KΩ ± 5% 1/2W	6100-3205	01121	RC20GF203J	5905-192-0649
R447	Composition,	20KΩ ± 5% 1/2W	6100-3205	01121	RC20GF203J	5905-192-0649
R448	Composition,	160Ω ± 5% 1/2W	6100-1165	01121	RC20GF161J	5905-256-0415
R449	Composition,	620Ω ± 5% 1/2W	6100-1625	01121	RC20GF621J	5905-279-1761
R450	Composition,	4.7KΩ ± 5% 1/2W	6100-2475	01121	RC20GF472J	5905-279-3504
R451	Composition,	4.7KΩ ± 5% 1/2W	6100-2475	01121	RC20GF472J	5905-279-3504
R452	Composition,	620Ω ± 5% 1/2W	6100-1625	01121	RC20GF621J	5905-279-1761
R453	Composition,	4.7KΩ ± 5% 1/2W	6100-2475	01121	RC20GF472J	5905-279-3504
R454	Composition,	20KΩ ± 5% 1/2W	6100-3205	01121	RC20GF203J	5905-192-0649
R455	Composition,	20KΩ ± 5% 1/2W	6100-3205	01121	RC20GF203J	5905-192-0649
R456	Composition,	160Ω ± 5% 1/2W	6100-1165	01121	RC20GF161J	5905-256-0415
R457	Composition,	620Ω ± 5% 1/2W	6100-1625	01121	RC20GF621J	5905-279-1761
R458	Composition,	4.7KΩ ± 5% 1/2W	6100-2475	01121	RC20GF472J	5905-279-3504
R459	Composition,	4.7KΩ ± 5% 1/2W	6100-2475	01121	RC20GF472J	5905-279-3504
R460	Composition,	620Ω ± 5% 1/2W	6100-1625	01121	RC20GF621J	5905-279-1761
R461	Composition,	4.7KΩ ± 5% 1/2W	6100-2475	01121	RC20GF472J	5905-279-3504
R462	Composition,	20KΩ ± 5% 1/2W	6100-3205	01121	RC20GF203J	5905-192-0649
R463	Composition,	20KΩ ± 5% 1/2W	6100-3205	01121	RC20GF203J	5905-192-0649
R464	Composition,	15KΩ ± 5% 1/2W	6100-3155	01121	RC20GF153J	5905-279-2616
R465	Composition,	15KΩ ± 5% 1/2W	6100-3155	01121	RC20GF153J	5905-279-2616
R466	Composition,	15KΩ ± 5% 1/2W	6100-3155	01121	RC20GF153J	5905-279-2616
R467	Composition,	15KΩ ± 5% 1/2W	6100-3155	01121	RC20GF153J	5905-279-2616
R468	Composition,	15KΩ ± 5% 1/2W	6100-3155	01121	RC20GF153J	5905-279-2616
R469	Composition,	15KΩ ± 5% 1/2W	6100-3155	01121	RC20GF153J	5905-279-2616
R470	Composition,	15KΩ ± 5% 1/2W	6100-3155	01121	RC20GF153J	5905-279-2616
R471	Composition,	100Ω ± 10% 2W	6120-1109	01121	HB, 100Ω + 10%	5905-279-2616
TRANSISTORS						
Q401	Type	2N3646	8210-1119	07263	2N3646	
Q402	Type	2N3646	8210-1119	07263	2N3646	
Q403	Type	2N3646	8210-1119	07263	2N3646	
Q404	Type	2N3646	8210-1119	07263	2N3646	
Q405	Type	2N3646	8210-1119	07263	2N3646	
Q406	Type	2N3646	8210-1119	07263	2N3646	
Q407	Type	2N3646	8210-1119	07263	2N3646	
Q408	Type	2N3646	8210-1119	07263	2N3646	
Q409	Type	2N3646	8210-1119	07263	2N3646	
Q410	Type	2N3646	8210-1119	07263	2N3646	
Q411	Type	2N3646	8210-1119	07263	2N3646	
Q412	Type	2N3646	8210-1119	07263	2N3646	
Q413	Type	2N3646	8210-1119	07263	2N3646	
Q414	Type	2N3646	8210-1119	07263	2N3646	
Q415	Type	2N3646	8210-1119	07263	2N3646	
Q416	Type	2N3646	8210-1119	07263	2N3646	



NOTE

The number shown on the foil side of the board is not the part number for the complete assembly. This assembly number is given in the caption.

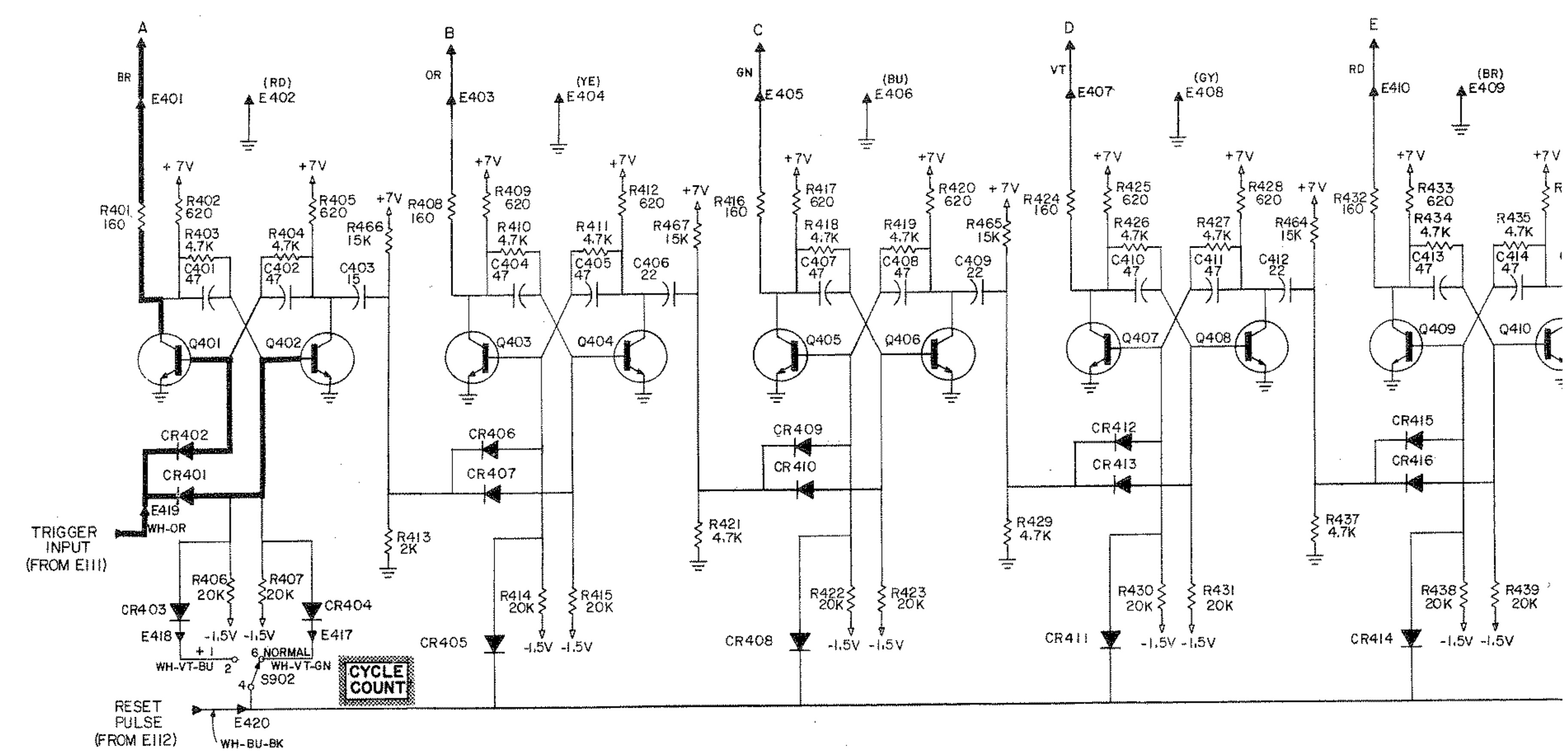
The dot on the foil at the transistor socket indicates the collector lead.

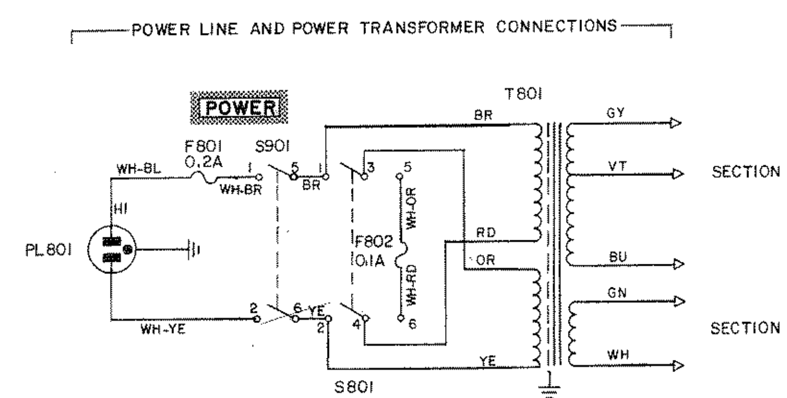
Figure 7-5. Etched-circuit board assembly, scaler circuit and power supply (P/N 1396-2761).

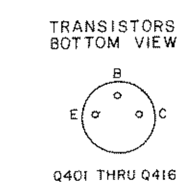
NOTE UNLESS SPECIFIED

1. POSITION OF ROTARY SWITCHES SHOWN COUNTERCLOCKWISE.
2. CONTACT NUMBERING OF SWITCHES EXPLAINED ON SEPARATE SHEET SUPPLIED IN INSTRUCTION BOOK.
3. REFER TO SERVICE NOTES IN INSTRUCTION BOOK FOR VOLTAGES APPEARING ON DIAGRAM.
4. RESISTORS 1/2 WATT.
5. RESISTANCE IN OHMS K = 1000 OHMS M = 1 MEGOHM
6. CAPACITANCE VALUES ONE AND OVER IN PICOFARADS, LESS THAN ONE IN MICROFARADS.
7. ◯ KNOB CONTROL
8. SCREWDRIVER CONTROL
9. E - ANCHOR TERMINAL
10. TP - TEST POINT

OUTPUT LEAVES SUBASSEMBLY
INPUT FROM DIFFERENT SUBASSEMBLY
OUTPUT REMAINS ON SUBASSEMBLY
INPUT FROM SAME SUBASSEMBLY







NOTE UNLESS SPECIFIED

1. POSITION OF ROTARY SWITCHES SHOWN COUNTERCLOCKWISE.
2. CONTACT NUMBERING OF SWITCHES EXPLAINED ON SEPARATE SHEET SUPPLIED IN INSTRUCTION BOOK.
3. REFER TO SERVICE NOTES IN INSTRUCTION BOOK FOR VOLTAGES APPEARING ON DIAGRAM.
4. RESISTORS 1/2 WATT.
5. RESISTANCE IN OHMS K-1000 OHMS M-1 MEGOHM
6. CAPACITANCE VALUES ONE AND OVER IN PICOFARADS, LESS THAN ONE IN MICROFARADS.
7. ◯ KNOB CONTROL
8. SCREWDRIVER CONTROL
9. E - ANCHOR TERMINAL
10. TP - TEST POINT

OUTPUT LEAVES SUBASSEMBLY
INPUT FROM DIFFERENT SUBASSEMBLY
OUTPUT REMAINS ON SUBASSEMBLY
INPUT FROM SAME SUBASSEMBLY

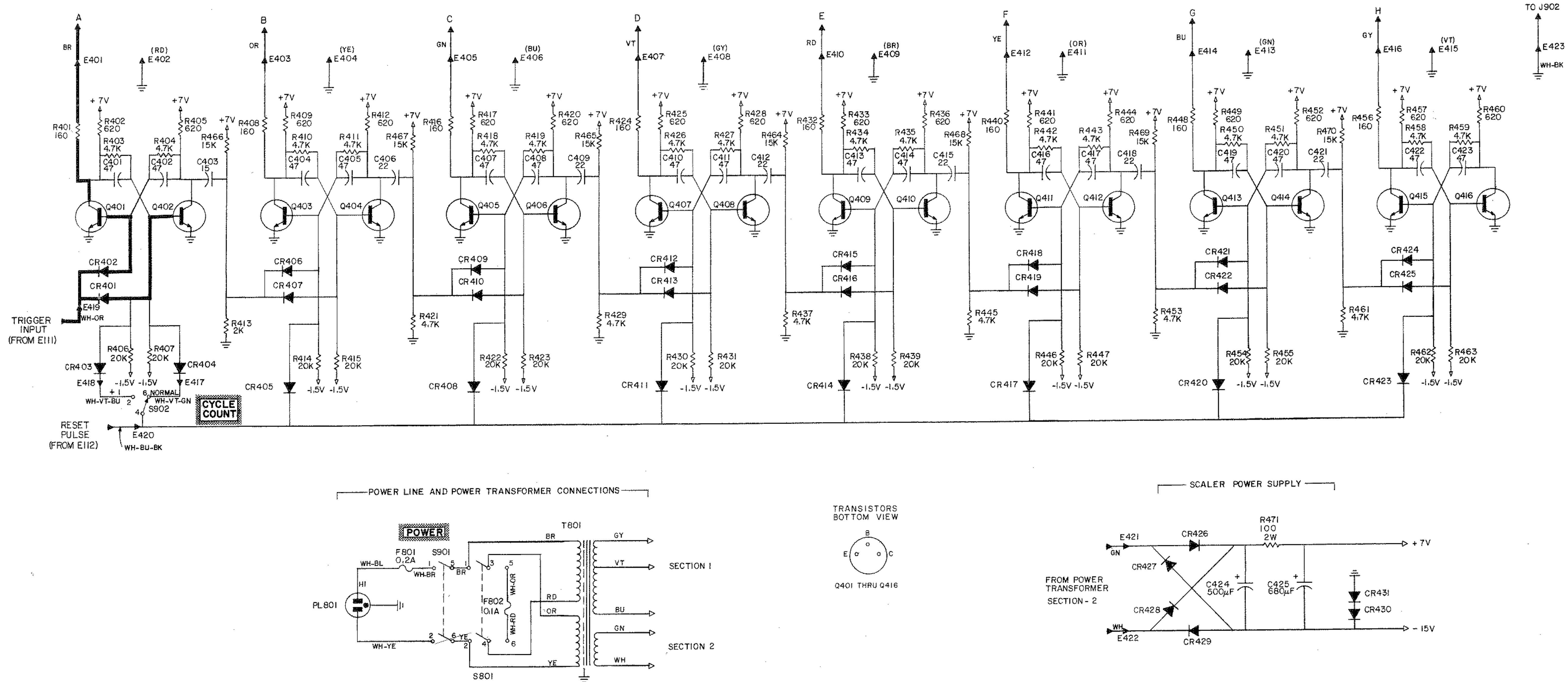


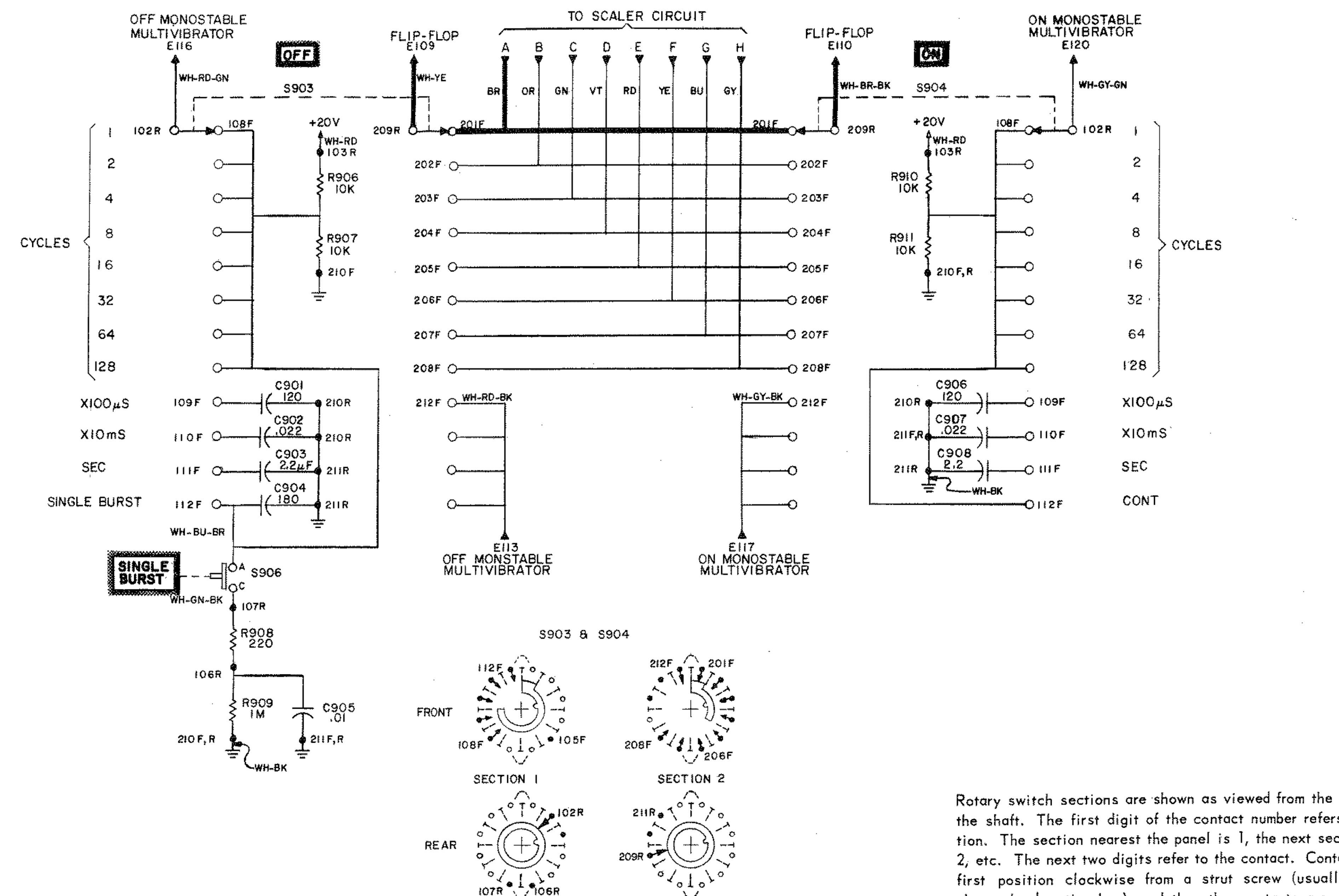
Figure 7-6. Scaler circuit and power supply and power transformer schematic diagram.

NOTE UNLESS SPECIFIED

1. POSITION OF ROTARY SWITCHES SHOWN COUNTERCLOCKWISE.
2. CONTACT NUMBERING OF SWITCHES EXPLAINED ON SEPARATE SHEET SUPPLIED IN INSTRUCTION BOOK.
3. REFER TO SERVICE NOTES IN INSTRUCTION BOOK FOR VOLTAGES APPEARING ON DIAGRAM.
4. RESISTORS 1/2 WATT.
5. RESISTANCE IN OHMS K - 1000 OHMS M - 1 MEGOHM
6. CAPACITANCE VALUES ONE AND OVER IN PICOFARADS, LESS THAN ONE IN MICROFARADS.
7. ◯ KNOB CONTROL
8. ⬤ SCREWDRIVER CONTROL
9. ⊈ - ANCHOR TERMINAL
10. TP - TEST POINT

E - 109, 110, 113, 116, 117, 120 ARE ON MAIN CIRCUIT

OUTPUT LEAVES SUBASSEMBLY
INPUT FROM DIFFERENT SUBASSEMBLY
OUTPUT REMAINS ON SUBASSEMBLY
INPUT FROM SAME SUBASSEMBLY

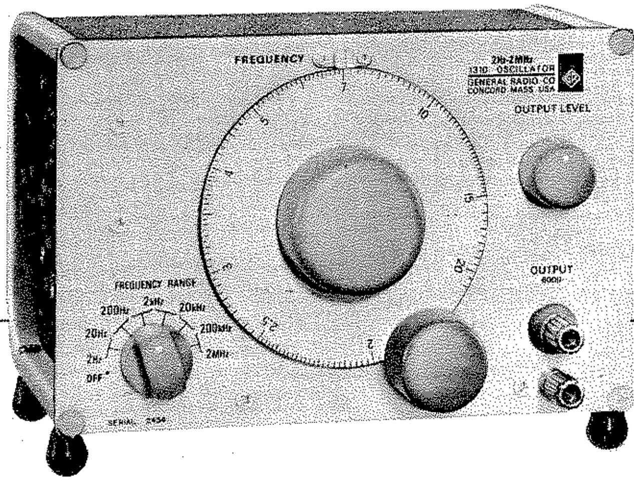


Rotary switch sections are shown as viewed from the panel end of the shaft. The first digit of the contact number refers to the section. The section nearest the panel is 1, the next section back is 2, etc. The next two digits refer to the contact. Contact 01 is the first position clockwise from a strut screw (usually the screw above the locating key), and the other contacts are numbered sequentially (02, 03, 04, etc), proceeding clockwise around the section. A suffix F or R indicates that the contact is on the front or rear of the section, respectively.

Figure 7-7. Schematic diagram of the OUTPUT ON, ON TIME, OUTPUT OFF, OFF TIME and SINGLE BURST switches and controls.

OSCILLATOR

Type 1310-A



- 2 Hz to 2 MHz
- 20-V, constant output, ±2%
- 0.25% distortion

The superior characteristics of this oscillator make it an exceptionally useful laboratory signal source.

Constant output over a very wide frequency range facilitates frequency-response measurements.

High-resolution dial and exceptional amplitude and frequency stability are important for measurements of filters and narrow-band devices.

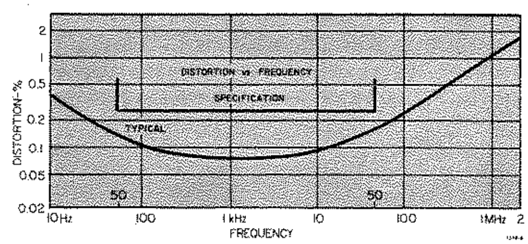
Equally useful in 600-ohm and 50-ohm circuits, since distortion is independent of load, even a short circuit.

When phase-locked to a frequency standard, the oscillator can deliver a high-level standard-frequency output with adjustable amplitude and low distortion.

DESCRIPTION

A capacitance-tuned, RC Wien-bridge oscillator drives a low-distortion output amplifier, which isolates the oscillator from the load and delivers a constant voltage behind 600 ohms.

A jack is provided for introduction of a synchronizing



signal for phase locking or to furnish a signal, independent of the output attenuator setting, to operate a counter, or to synchronize an oscilloscope or another oscillator.

Seven transistors, one nuvistor, and ingenious design make the 1310-A Oscillator not only rugged, reliable, and insensitive to mechanical vibration but also compact and light in weight.

— See **GR Experimenter** for August 1965.

specifications

FREQUENCY

Range: 2 Hz to 2 MHz in 6 decade ranges. Overlap between ranges, 5%.

Accuracy: ±2% of setting.

Stability (typical at 1 kHz): Warmup drift, 0.1%. After warmup: 0.003% short term (10 min), 0.03% long term (12 h).

Controls: Continuously adjustable main dial covers decade range in 305°, vernier in 4 turns.

Synchronization: Frequency can be locked to external signal. Lock range ±3% per volt rms input up to 10 V. Frequency dial functions as phase adjustment.

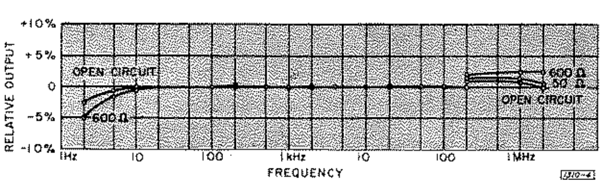
OUTPUT

Voltage: >20 V open circuit.

Power: >160 mW into 600 Ω.

Impedance: 600 Ω. One terminal grounded.

Attenuation: Continuously adjustable attenuator with >46-dB range.



Distortion: <0.25%, 50 Hz to 50 kHz with any linear load. Oscillator will drive a short circuit without clipping.

Hum: <0.02%, independent of attenuator setting.

Amplitude vs Frequency: ±2%, 20 Hz to 200 kHz, into open circuit or 600-Ω load.

Synchronization: Constant-amplitude (0.8-V), high-impedance (27-kΩ) output to drive counter or oscilloscope.

GENERAL

Power Required: 105 to 125, 195 to 235, or 210 to 250 V, 50 to 400 Hz, 12 W.

Terminals: Output, GR 938 Binding Posts; sync, side-panel telephone jack.

Accessories Supplied: Power cord, spare fuses.

Accessories Available: Adaptor cable 1560-P95 (telephone plug to double plug); rack-adaptor set.

Mounting: Convertible-bench cabinet.

Dimensions (width x height x depth): 8 x 6 x 8⅛ in. (205 x 155 x 210 mm).

Weight: Net, 7¾ lb (3.6 kg); shipping, 10 lb (4.6 kg).

Catalog Number	Description
1310-9701	**1310-A Oscillator**
1560-9695	**1560-P95 Adaptor Cable**
0480-9838	**480-P308 Rack-Adaptor Set**

FEDERAL MANUFACTURERS CODE

From Federal Supply Code for Manufacturers Cataloging Handbooks H4-1 (Name to Code) and H4-2 (Code to Name) as supplemented through June, 1967.

Code	Manufacturers Name and Address
00192	Jones Mfg. Co., Chicago, Illinois
00194	Walsco Electronics Corp., Los Angeles, Calif.
00656	Aerovox Corp., New Bedford, Mass.
01009	Alden Products Co., Brockton, Mass.
01121	Allen-Bradley, Co., Milwaukee, Wisc.
01295	Texas Instruments, Inc., Dallas, Texas
02114	Ferroxcube Corp. of America, Saugerties, N. Y. 12477
02606	Fenwal Lab. Inc., Morton Grove, Ill.
02660	Amphenol Electronics Corp., Broadview, Ill.
02768	Fastex Division of Ill. Tool Works, Des Plaines, Ill. 60016
03508	G. E. Semiconductor Products Dept., Syracuse, N. Y. 13201
03636	Grayburne, Yonkers, N. Y. 10701
03888	Pyrofilm Resistor Co., Cedar Knolls, N. J.
03911	Clairex Corp., New York, N. Y. 10001
04009	Arrow, Hart and Hegeman Electric Co., Hartford, Conn. 06106
04713	Motorola Semi-Conduct Product, Phoenix, Ariz. 85008
05170	Engineered Electronics Co., Inc., Santa Ana, Calif. 92702
05624	Barber-Colman Co., Rockford, Ill. 61101
05820	Wakefield Eng., Inc., Wakefield, Mass. 01880
07127	Eagle Signal Div. of E. W. Bliss Co., Baraboo, Wisc.
07261	Avnet Corp., Culver City, Calif. 90230
07263	Fairchild Camera and Instrument Corp., Mountain View, Calif.
07387	Birtcher Corp., No. Los Angeles, Calif.
07595	American Semiconductor Corp., Arlington Heights, Ill. 60004
07828	Bodine Corp., Bridgeport, Conn. 06605
07829	Bodine Electric Co., Chicago, Ill. 60618
07910	Continental Device Corp., Hawthorne, Calif.
07983	State Labs Inc., N. Y., N. Y. 10003
07999	Amphenol Corp., Borg Inst. Div., Delavan, Wisc. 53115
08730	Vemaline Prod. Co., Franklin Lakes, N. J.
09213	General Electric Semiconductor, Buffalo, N. Y.
09408	Star-Tronics Inc., Georgetown, Mass. 01830
09823	Burgess Battery Co., Freeport, Ill.
09922	Burndy Corp., Norwalk, Conn. 06852
11236	C.P.S. of Berne, Inc., Berne, Ind. 46711
11599	Chandler Evans Corp., W. Hartford, Conn.
12498	Teledyn Inc., Crystalonics Div., Cambridge, Mass. 02140
12672	RCA Commercial Receiving Tube and Semiconductor Div., Woodridge, N.J.
12697	Clarostat Mfg. Co. Inc., Dover, N. H. 03820
12954	Dickson Electronics Corp., Scottsdale, Ariz.
13327	Solitron Devices, Tappan, N. Y. 10983
14433	ITT Semiconductors, W. Palm Beach, Florida
14655	Cornell Dubilier Electric Co., Newark N. J.
14674	Corning Glass Works, Corning, N. Y.
14936	General Instrument Corp., Hicksville, N. Y.
15238	ITT, Semiconductor Div. of Int. T. and T, Lawrence, Mass.
15605	Cutler-Hammer Inc., Milwaukee, Wisc. 53233
16037	Spruce Pine Mica Co., Spruce Pine, N. C.
19644	LRC Electronics, Horseheads, New York
19701	Electra Mfg. Co., Independence, Kansas 67301
21335	Fafnir Bearing Co., New Briton, Conn.
24446	G. E. Schenectady, N. Y. 12305
24454	G. E., Electronic Comp., Syracuse, N. Y.
24455	G. E. (Lamp Div), Nela Park, Cleveland, Ohio
24655	General Radio Co., W. Concord, Mass 01781
26806	American Zettler Inc., Costa Mesa, Calif.
28520	Hayman Mfg. Co., Kenilworth, N. J.
28959	Hoffman Electronics Corp., El Monte, Calif.
30874	International Business Machines, Armonk, N.Y.
32001	Jensen Mfg. Co., Chicago, Ill. 60638
35929	Constanta Co. of Canada Limited, Montreal 19, Quebec
37942	P. R. Mallory and Co. Inc., Indianapolis, Ind.
38443	Marlin-Rockwell Corp., Jamestown, N. Y.
40931	Honeywell Inc., Minneapolis, Minn. 55408
42190	Muter Co., Chicago, Ill. 60638
42498	National Co. Inc., Melrose, Mass. 02176
43991	Norma-Hoffman Bearings Corp., Stanford, Conn. 06904
49671	RCA, New York, N. Y.
49956	Raytheon Mfg. Co., Waltham, Mass. 02154
53021	Sangamo Electric Co., Springfield, Ill. 62705
54294	Shallcross Mfg. Co., Selma, N. C.
54715	Shure Brothers, Inc., Evanston, Ill.
56289	Sprague Electric Co., N. Adams, Mass.
59730	Thomas and Betts Co., Elizabeth, N. J. 07207
59875	TRW Inc. (Accessories Div), Cleveland, Ohio
60399	Torrington Mfg. Co., Torrington, Conn.
61637	Union Carbide Corp., New York, N. Y. 10017
61864	United-Carr Fastener Corp., Boston, Mass.
63060	Victoreen Instrument Co., Inc., Cleveland, Ohio
63743	Ward Leonard Electric Co., Mt. Vernon, N. Y.
65083	Westinghouse (Lamp Div), Bloomfield, N. J.
65092	Weston Instruments, Weston-Newark, Newark, N. J.
70485	Atlantic-India Rubber Works, Inc., Chicago, Ill. 60607
70563	Amperite Co., Union City, N. J. 07087
70903	Belden Mfg. Co., Chicago, Ill. 60644
71126	Bronson, Homer D., Co., Beacon Falls, Conn.
71294	Canfield, H. O. Co., Clifton Forge, Va. 24422
71400	Bussman Mfg. Div. of McGraw Edison Co., St. Louis, Mo.
71590	Centralab, Inc., Milwaukee, Wisc. 53212
71666	Continental Carbon Co., Inc., New York, N. Y.
71707	Coto Coil Co. Inc., Providence, R. I.
71744	Chicago Miniature Lamp Works, Chicago, Ill.
71785	Cinch Mfg. Co. and Howard B. Jones Div., Chicago, Ill. 60624
71823	Darnell Corp., Ltd., Downey, Calif. 90241
72136	Electro Motive Mfg. Co., Willmington, Conn.
72259	Nytronics Inc., Berkeley Heights, N. J. 07922
72619	Dialight Co., Brooklyn, N. Y. 11237
72699	General Instrument Corp., Capacitor Div., Newark, N. J. 07104
72765	Drake Mfg. Co., Chicago, Ill. 60656
72825	Hugh H. Eby, Inc., Philadelphia, Penn. 19144
72962	Elastic Stop Nut Corp., Union, N. J. 07083
72982	Erie Technological Products Inc., Erie, Penn.
73138	Beckman, Inc., Fullerton, Calif. 92634
73445	Amperex Electronics Co., Hicksville, N. Y.
73559	Carling Electric Co., W. Hartford, Conn.
73690	Elco Resistor Co., New York, N. Y.
73899	J. F. D. Electronics Corp., Brooklyn, N. Y.
74193	Heinemann Electric Co., Trenton, N. J.
74861	Industrial Condenser Corp., Chicago, Ill.
74970	E. F. Johnson Co., Waseca, Minn. 56093
75042	IRC Inc., Philadelphia, Penn. 19108
75382	Kulka Electric Corp., Mt. Vernon, N. Y.
75491	Lafayette Industrial Electronics, Jamaica, N.Y.
75608	Linden and Co., Providence, R. I.
75915	Littelfuse, Inc., Des Plaines, Ill. 60016
76005	Lord Mfg. Co., Erie, Penn. 16512
76149	Malloy Electric Corp., Detroit, Mich. 48204
76487	James Millen Mfg. Co., Malden,Mass. 02148
76545	Mueller Electric Co., Cleveland, Ohio 44114
76684	National Tube Co., Pittsburg, Penn.
76854	Oak Mfg. Co., Crystal Lake, Ill.
77147	Patton MacGuyer Co., Providence, R. I.
77166	Pass-Seymour, Syracuse, N. Y.
77263	Pierce Roberts Rubber Co., Trenton, N. J.
77339	Positive Lockwasher Co., Newark , N. J.
77542	Ray-O-Vac Co., Madison, Wisc.
77630	TRW, Electronic Component Div., Camden, N. J. 08103
77638	General Instruments Corp., Brooklyn, N. Y.
78189	Shakeproof Div. of Ill. Tool Works, Elgin, Ill. 60120
78277	Sigma Instruments Inc., S. Braintree, Mass.
78488	Stackpole Carbon Co., St. Marys, Penn.
78553	Tinnerman Products, Inc., Cleveland, Ohio
79089	RCA, Commercial Receiving Tube and Semiconductor Div., Harrison, N. J.
79725	Wiremold Co., Hartford, Conn. 06110
79963	Zierick Mfg. Co., New Rochelle, N. Y.
80030	Prestole Fastener Div. Bishop and Babcock Corp., Toledo, Ohio
80048	Vickers Inc. Electric Prod. Div., St. Louis, Mo.
80131	Electronic Industries Assoc., Washington, D.C.
80183	Sprague Products Co., N. Adams, Mass.
80211	Motorola Inc., Franklin Park, Ill. 60131
80258	Standard Oil Co., Lafeyette, Ind.
80294	Bourns Inc., Riverside, Calif. 92506
83033	Meissner Mfg., Div. of Maguire Industries, Inc. Mount Carmel, Illinois
80431	Air Filter Corp., Milwaukee, Wisc. 53218
80583	Hammarlund Co. Inc., New York, N. Y.
80740	Beckman Instruments, Inc., Fullerton, Calif.
81073	Grayhill Inc., LaGrange, Ill. 60525
81143	Isolantite Mfg. Corp., Stirling, N. J. 07980
81349	Military Specifications
81350	Joint Army-Navy Specifications
81751	Columbus Electronics Corp., Yonkers, N. Y.
81831	Filton Co., Flushing, L. I., N. Y
81860	Barry Controls Div. of Barry Wright Corp., Watertown, Mass.
82219	Sylvania Electric Products, Inc., (Electronic Tube Div.), Emporium, Penn.
82273	Indiana Pattern and Model Works, LaPort, Ind.
82389	Switchcraft Inc., Chicago, Ill. 60630
82647	Metals and Controls Inc., Attleboro, Mass.
82807	Milwaukee Resistor Co., Milwaukee, Wisc.
83058	Carr Fastener Co., Cambridge, Mass.
83186	Victory Engineering Corp (IVECO), Springfield, N. J. 07081
83361	Bearing Specialty Co., San Francisco, Calif.
83587	Solar Electric Corp., Warren, Penn.
83740	Union Carbide Corp., New York, N. Y. 10017
84411	TRW Capacitor Div., Ogallala, Nebr.
84835	Lehigh Metal Products Corp., Cambridge, Mass. 02140
84971	TA Mfg. Corp., Los Angeles, Calif.
86577	Precision Metal Products of Malden Inc., Stoneham, Mass. 02180
86684	RCA (Electrical Component and Devices) Harrison, N. J.
86800	Continental Electronics Corp. Brooklyn, N.Y. 11222
88140	Cutler-Hammer Inc., Lincoln, Ill.
88219	Gould Nat. Batteries Inc., Trenton, N. J.
88419	Cornell Dubilier Electric Corp., Fuquay-Varina, N. C.
88627	K and G Mfg. Co., New York, N. Y.
89482	Holtzer Cabot Corp., Boston, Mass.
89665	United Transformer Co., Chicago, Ill.
90201	Mallory Capacitor Co., Indianapolis, Ind.
90750	Westinghouse Electric Corp., Boston, Mass.
90952	Hardware Products Co., Reading, Penn. 19602
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Printed in USA